Ontario Geological Survey

Study 23

Orientation Overburden Geochemistry and Quaternary Geology Investigations of Carbonatite-Alkalic Complexes in the

Prairie Lake and Killala Lake Areas

District of Thunder Bay

By

L.G. Closs and E.V. Sado

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Deputy Minister

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FOREWORD

GEOCHEMISTRY AND QUATERNARY GEOLOGY: CARBONATITE-ALKALIC COMPLEXES, PRAIRIE LAKE-KILLALA LAKE AREAS

This study represents part of an Ontario Geological Survey program designed to provide state of the art evaluation of the geology and mineral potential of carbonatite-alkalic rocks in Ontario. These complexes are both extremely interesting and perplexing in their lithostructure, petrogenesis, and metallogeny.

Orientation overburden geochemical research in the Prairie Lake-Killala Lake areas provides valuable baseline information for development of geochemical exploration strategies in carbonatite-alkalic terranes.

E.G. Pye
Director
Ontario Geological Survey

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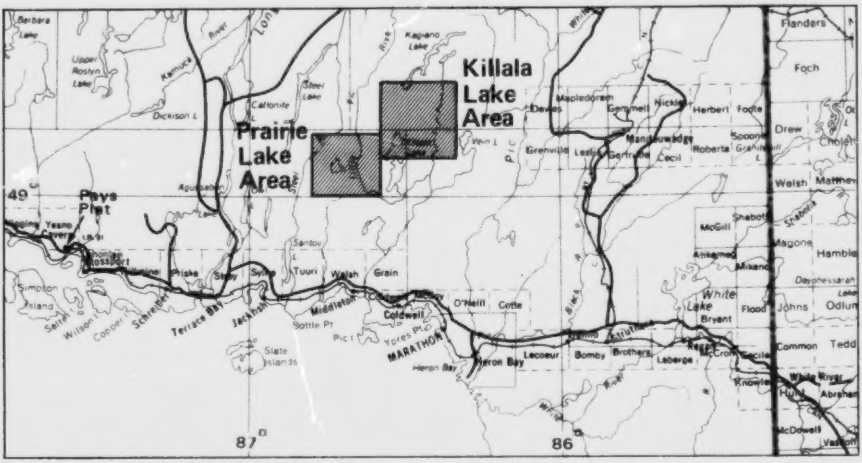

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

Figure 1–Key map showing location of areas studied.

ABSTRACT

Carbonatite-alkalic complexes are potential hosts for deposits of niobium (columbium) and tantalum, rare earth elements of the cerium subgroup, and uranium and thorium. Circular to elliptical, high intensity aeromagnetic anomalies are characteristic of these complexes, and their presence has been inferred on this basis. Many localities in northern Ontario characterized by such patterns are largely covered by overburden; hence, bedrock geology evaluation of these targets is severely restricted. Elsewhere, in geologically favourable terrains such as the Kapuskasing Structural Zone, regional magnetics may mask the more subtle, local magnetic patterns indicative of intrusive centres. With the diagnostic chemistry of these rock types in mind, orientation geochemical studies were carried out in two areas, Prairie Lake and Killala Lake, where preliminary bedrock mapping was available; the investigations consisted of vegetation and shallow overburden sampling and an infrared airphoto survey. This report presents the results of the overburden geochemistry part of the project.

Sampling of 'B' horizon soil and overburden material was done on three scales within each of two areas:

Reconnaissance overburden sampling was carried out over the entire Prairie Lake carbonatite. Samples of 'B' horizon soil and overburden material were collected from stations on a 305 m square grid oriented N45°E and N45°W, parallel and perpendicular respectively to the regional ice transport direction. Intermediate-scale sampling comprised collection of the same materials at 76 m intervals along reconnaissance grid lines oriented N45°E and spaced 305 m apart. This block measures 914 m parallel to the ice transport direction by 610 m in width. It covers an area on the southwest flank of the carbonatite in which all rock units known to exist in the complex are represented and where the majority of the exploration work has been concentrated. Detailed sampling was undertaken over one of the most economically interesting parts of the intermediate-scale sample block. Sample sites were located at 30 m intervals along three lines (each 305 m long) oriented N45°E and spaced 76 m apart.

At Killala Lake, a block measuring 2133 m by 1525 m, parallel and perpendicular respectively to the regional ice transport direction of N45°E, was selected for reconnaissance sampling at sites on a 305 m square grid. The area is situated on the southwest flank of the intrusion and contains four at the five major lithologic members of the complex and one of the two known zones of copper-nickel mineralization. Detailed sampling was conducted at 61 m intervals on lines oriented parallel to the regional direction of ice movement and spaced 76 m apart. In this area, the detailed sampling was confined to: (1) the contact between syenitic and syenodioritic rocks exposed south of Kentron Lake in the interior of the complex where niobium mineralization had been reported, and (2) across the gabbroic rocks within the reconnaissance sampling block, where copper-nickel mineralization was known to be associated with the olivine gabbros.

Soil and overburden samples were oven-dried at 80°C. Overburden samples were passed through a series of stainless-steel Tyler sieves containing 16, 60, and 250 mesh screens, whereas the 'B' horizon soil samples were only passed through an 80 mesh screen. The −80 mesh fraction of 'B' horizon soils, the −250 mesh fraction of tills, and the heavy mineral separate (using tetrabromethane, specific gravity 2.96) of the −60 +250 mesh fraction of tills were analyzed for:

1) hot HNO_3 - HCl extractable Cu, Zn, Pb, Ni, Co, Mn, and Cr by atomic absorption spectrophotometry;

2) Ba, Sr, Nb, La, Y, Zr, and Ti by DC arc emission spectrography (except that, because of the higher concentrations involved, titanium in the heavy mineral separate was determined by atomic absorption spectrophotometry and expressed as the oxide); and

3) Mo and P by colorimetric-gravimetric procedures.

A number of sites were sampled in duplicate and these samples in turn were chemically analyzed in duplicate to establish the magnitude and proportion of the total variability contributed by analytical, sampling, and regional variance components. This sampling design-analysis of variance approach was employed to select the most geochemically stable pathfinder elements.

The results obtained from the study indicate the optimum trace element suites for identifying the major bedrock units and mineralized zones within each area at the three levels at which sampling was conducted; they also provide baseline data for trace element concentrations in soils and overburden developed over carbonatitic and alkalic lithologies. The data can be used in establishing meaningful threshold values for geochemical surveys carried out to evaluate the mineral potential of other known or inferred carbonatite-alkalic complexes elsewhere in the province.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

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By

L.G. Closs[1] and E.V. Sado[2]

INTRODUCTION

Carbonatite-alkalic complexes are potential hosts for deposits of niobium (columbium) and tantalum, rare earth elements of the cerium subgroup, and uranium and thorium (de Kun 1962; Heinrich 1966). Economic concentrations of iron, titanium, manganese, copper, apatite, barite, fluorite, vermiculite, nepheline, and carbonate rock may also be associated with these rock types, and zirconium and strontium may prove to be by-products. The initial recognition and mineral assessment of these complexes was largely the result of the extensive search for radioactive mineralization (principally uranium) conducted during the period 1950 to 1956. Previous work on carbonatite-alkalic complexes by the Ontario Geological Survey is summarized by Parsons (1961), Satterly (1970) and Ferguson (1972). In 1974, the Survey initiated a detailed program to assess the geology and mineral potential of the carbonatite-alkalic rocks in the province. The geochemical investigations outlined here constitute a supportive and complementary phase of the larger bedrock-mapping project being undertaken by R.P. Sage (1974) of the Precambrian Geology Section.

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The specific roles and responsibilities of the individual authors of this report were as follows: Closs designed and carried out the geochemical investigations and wrote the report, while Sado carried out the field investigation of the Quaternary geology.

Location and Access

Two areas were sampled during July and August of 1974. The Prairie Lake carbonatite-alkalic complex is located immediately northwest of Prairie Lake at Latitude 49°02′N and Longitude 86°43′W, approximately 42 km northwest of Marathon. The centre of the Killala Lake complex is situated at Latitude 49°10′N and Longitude 86°28′W, roughly 50 km north of Marathon. Access to both areas is via float-equipped aircraft, available from White River and Pays Plat (Figure 1).

Purpose and Scope of the Project

Circular to elliptical, high intensity aeromagnetic anomalies are characteristic of carbonatite-alkalic complexes and their presence has been inferred on this basis (Ferguson 1972). Many localities in northern Ontario characterized by such patterns are largely covered by overburden; hence, bedrock geology evaluation is severely restricted. Elsewhere, in geologically favourable terrains such as the Kapuskasing Structural Zone, regional magnetics may mask the more subtle, local magnetic patterns indicative of intrusive centres. With the diagnostic chemistry of these rock types in mind, orientation geochemical studies, consisting of shallow overburden and vegetation sampling and an infrared airphoto survey, were initiated in two areas where preliminary bedrock mapping had been completed and more detailed work was being conducted by R.P. Sage of the Precambrian Geology Section. The objectives of the project were:

1) to investigate metal dispersion in Quaternary deposits overlying the complexes as overburden;
2) to investigate metal dispersion in trees rooted in this material;
3) to compare these results with those of the bedrock mapping and geochemical studies by R.P. Sage;
4) to evaluate the effectiveness of the infrared airphoto survey as a means of portraying the documented ground conditions; and
5) to make recommendations for the optimum procedures to be used in the regional and detailed geological evaluation of carbonatite-alkalic complexes elsewhere in the province.

This report presents the results of the overburden geochemistry part of the study. Other aspects of the project are in preparation.

Acknowledgments

Field assistants were S.R. Parmar, who acted as senior assistant, and E. Janicki, N. Saunders, D. Smith, and W.S. Taylor. S.R. Parmar, H. Oiye and B. MacRae assisted considerably in the compilation of data and drafting of illustrations. All sample preparation and chemical analyses were undertaken by the staff of the Geoscience Laboratories, Ontario Geological Survey, Toronto under the supervision of A.E. Pitts, A.A. Tuemer, and J.B. Walsh. The cooperation of these individuals is gratefully acknowledged. In addition, the authors benefited from informal discussions, concerning the geology of the areas, with J.A. Coope, Newmont Exploration of Canada Limited; R.P. Sage, Precambrian Geology Section, Ontario Geological Survey; H.C. Sakrison, New Insco Mines Limited; and D.H. Watkinson, Department of Geology, Carleton University. Finally, we would like to acknowledge the editorial comments of R.F. Davie, Scientific Review Office, Ontario Geological Survey.

GEOLOGY

Prairie Lake Area

The geology of the Prairie Lake carbonatite-alkalic complex has been recently described by Sage (1975). The brief outline which follows is based largely upon this source which should be consulted for more detailed information regarding the geology and mineral occurrences of the area. Ontario Division of Mines Preliminary Map P.1070 (Sage 1976b), at a scale of 1 inch to 200 feet (1:24 000), was used to compile a base for the presentation of the geochemical results from this investigation.

BEDROCK GEOLOGY

The Prairie Lake complex, roughly 8.8 km^2 in plan, forms a circular topographic high northwest of Prairie Lake, where it intrudes felsic plutonic rocks of Early Precambrian (Archean) age (Figure 2). The contact is not exposed. Gittins *et al.* (1967) state that the complex is 1112 million years old. It is portrayed on the aeromagnetic map (ODM-GSC 1963a) as a strong, circular, magnetic anomaly (Figure 3).

The complex is composed of a complexly interfingering and concentrically distributed sequence of carbonate rock and pyroxene-nepheline rocks of the melteigite-urtite series. Members of the latter group are gradational into one another and are classified as ijolites. Ijolitic rocks predominate in the core of the complex, while carbonatitic rocks are more abundant on the periphery. Rapid lithological variation over distances of a few feet, exposed in exploration trenches, dictates that the geological contacts depicted on the preliminary map be considered tentative pending more detailed examination.

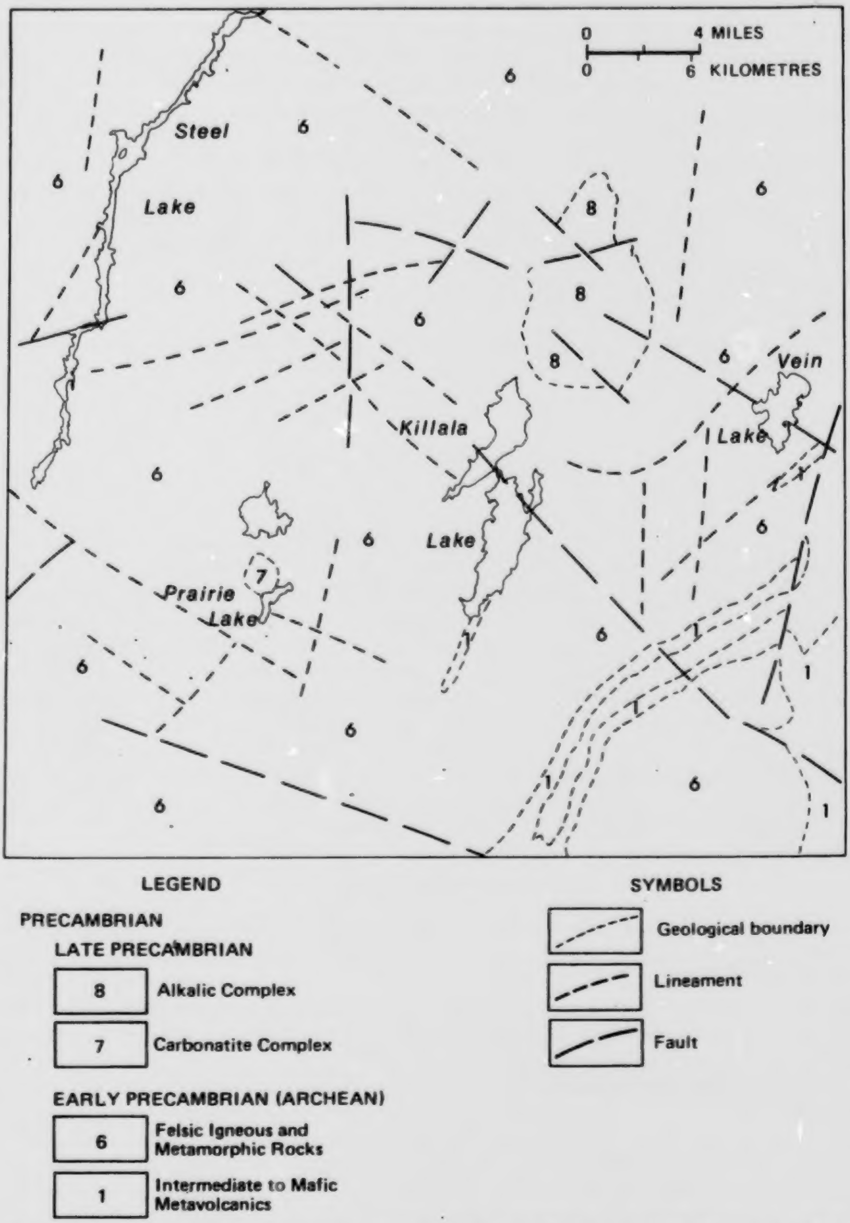


Figure 2–Compilation map of the regional bedrock geology (from Carter *et al.* 1973; Milne *et al.* 1972).

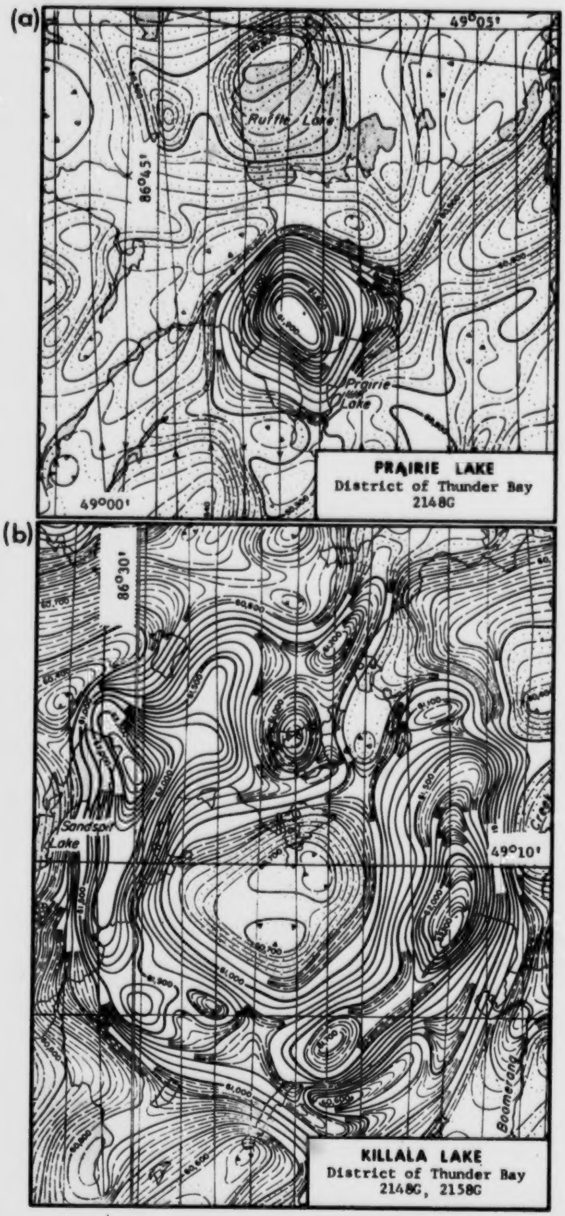


Figure 3–Aeromagnetic expression of (a) the Prairie Lake carbonatite-alkalic complex, and (b) the Killala Lake alkalic complex (from Ferguson 1972). Scale 1:126 720 or 1 inch to 2 miles.

ECONOMIC GEOLOGY AND MINERAL EXPLORATION

Within the complex, occurrences of uranium and niobium are associated with the mineral pyrochlore. "Jim's showing", southwest of Centre Lake, and the "North Highgrade showing", southeast of Anomaly Lake, are the two most promising uranium showings. Both are situated within or proximal to ijolitic rocks containing abundant wollastonite. Early exploration work consisted of geochemical soil sampling, ground magnetic and radiometric surveys, pitting and trenching, and diamond drilling (Assessment Files Research Office, Ontario Geological Survey, Toronto; Newmont Mining Corporation of Canada Limited, personal communications). This work indicated that "Jim's showing" contains an estimated 109,024 tons grading 0.12 percent U_3O_8. The zone has a probable strike length of 98 m and an average width of 7.0 m, and appears open in both directions (Sage 1975). Prospecting during the 1976 field season by New Insco Mines Limited was directed at testing for an extension of this zone between Centre and Anomaly Lakes.

SURFICIAL GEOLOGY

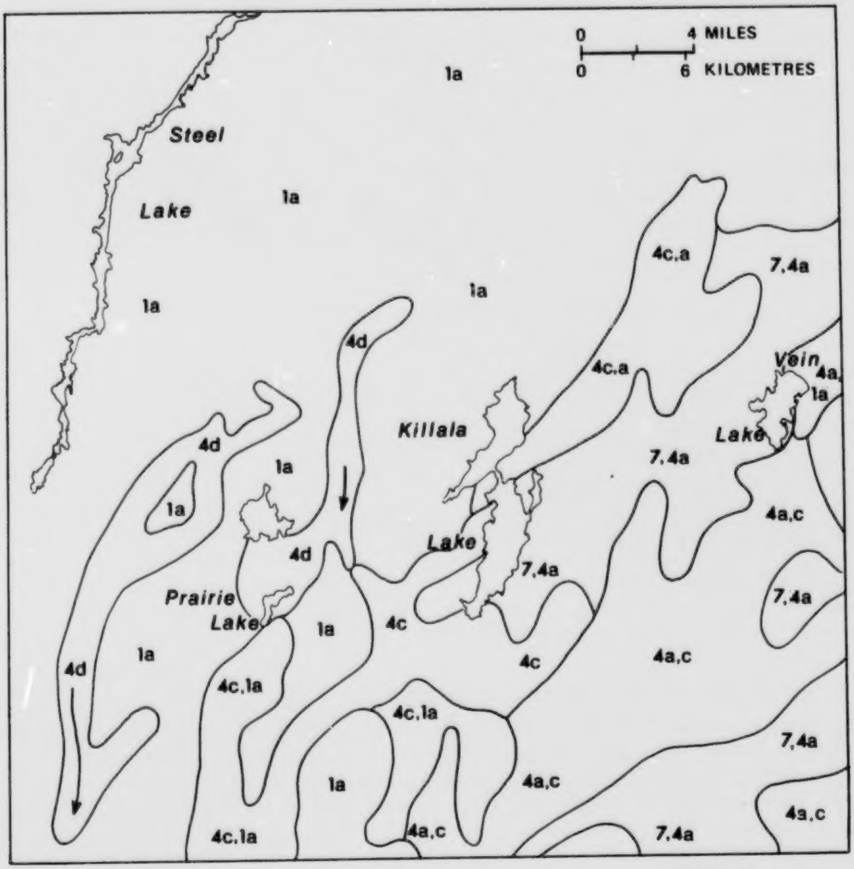
Zoltai (1965, 1967) indicated that the bedrock of the area is predominantly overlain by deltaic sand and valley train deposits (Figure 4). The intrusion, which forms a topographic high, is surrounded on three sides (Prairie Lake lies to the south) by sand flats and muskeg. On the hill itself, ablation till occurs in areas of deeper overburden, whereas an immature residual soil has developed from the weathering of shallowly buried bedrock. The occurrence of clasts of local rock types near the base of the ablation till suggests a possible mixing of ablation and basal till-residual soil facies.

Killala Lake Area

The geology of the Killala Lake alkalic complex has been described by Coates (1970) and Sage (1975); the outline presented below is based largely on these sources. Ontario Division of Mines Preliminary Map P.1069 (Sage 1976a), at a scale of 1 inch to ¼ mile (1:15 840), was used as a base for the presentation of the geochemical results.

BEDROCK GEOLOGY

The Killala Lake complex, approximately 109 km^2 in plan, is teardrop in outline with its long axis trending in a northerly direction. It consists of a series of high, arcuate hills standing as much as 170 m above the generally flat surrounding area, which is underlain by Early Precambrian (Archean) paragneisses. The complex is outlined on the aeromagnetic maps (ODM-GSC 1963a



LEGEND

CENOZOIC

PLEISTOCENE

7	Bare bedrock, eroded by lake action
4	Lacustrine deposits 4a Varved or massive clay and silt 4c Sand 4d Deltaic sand, valley train
1	Ground moraine 1a Silty to sandy till

SYMBOLS

← Spillway channel

Figure 4–Compilation map of the regional surficial geology (from Zoltai 1965).

and b) as a high contrast anomaly (Figure 3).

The complex is comprised of arcuate to almost completely circular lithologic units which are, from periphery to core: alkaline gabbro, nepheline syenite, and syenite. A horseshoe-shaped body of generally porphyritic syenodiorite is located in the centre of the complex. The contact between gabbroic and syenitic rocks is sharp and angular, whereas the contacts between nepheline syenite and syenite are frequently gradational. Dikes of feldspar porphyry, lamprophyre, and intrusive breccia are the youngest rocks mapped in the area.

ECONOMIC GEOLOGY AND MINERAL EXPLORATION

Copper-nickel mineralization is associated with an olivine-rich phase of the peripheral gabbro, and niobium occurrences are related to the presence of pyrochlore within nepheline syenite pegmatites in the central part of the complex. The latter feature is only a mineralogical curosity. Mineral exploration in the area was carried out by Baseline Mines Limited in 1954, Killala Lake Mines Limited in 1954, Maria Mining Corporation Limited in 1968, and Noranda Mines Limited in 1975 (Sage 1976b).

SURFICIAL GEOLOGY

Zoltai (1965, 1967) indicated that most of the intrusion is overlain by silty to sandy till, with lacustrine sand and varved or massive clay and silt flanking the complex on the south and east (Figure 4). Within the sampled areas, the overburden is predominantly ablation till. Immature residual soils have developed in areas of steep slopes and where bedrock lies near the surface. Between the ridges of gabbroic rocks and southwest of the margin of the complex, the overburden is a sandy material related to the discharge channel leading from Sandspit Lake south to Killala Lake.

GEOCHEMISTRY

Sampling Procedure

Reconnaissance overburden sampling was carried out over the entire Prairie Lake carbonatite. Samples of 'B' horizon soil and overburden material were collected from stations on a 305 m square grid oriented N45°E and N45°W, parallel and perpendicular respectively to the regional ice transport direction (Zoltai 1965, 1967). Intermediate-scale sampling comprised collection of the same materials at 76 m intervals along reconnaissance grid lines oriented N45°E and spaced 305 m apart. This block measures 914 m parallel to the ice transport direction, by 610 m in width. It covers an area on the southwest flank of the carbonatite in which all rock units known to exist in the complex are represented and where the majority of the exploration work has been concentrated. Detailed sampling was undertaken over one of the most economically interesting parts of the intermediate-scale sample block. Sample sites were located at 30 m intervals along three lines (each 305 m long) oriented N45°E and spaced 76 m apart. Sites were located by pace-and-compass traverses tied to prominent landmarks on 1:15 840 (1 inch to ¼ mile) scale air photographs and to an exploration grid established by Newmont Mining Corporation of Canada Limited in 1968. A number of sites were sampled in duplicate so that sampling variability could be estimated. A total of 130 'B' horizon soil and till samples were collected from the Prairie Lake area.

At Killala Lake, a block measuring 2133 m by 1525 m, parallel and perpendicular respectively to the regional ice transport direction of N45°E, was selected for reconnaissance sampling at sites on a 305 m square grid. The area is situated on the southwest flank of the intrusion and contains four of the five major lithologic members of the complex and one of the two known zones of copper-nickel mineralization. Detailed sampling was conducted at 61 m intervals on lines oriented parallel to the regional ice transport direction and spaced 76 m apart. In this area, the detailed sampling was confined to (1) the contact between syenitic and syenodioritic rocks exposed south of Kentron Lake in the interior of the complex where niobium mineralization had been reported (Coates 1970), and (2) across the gabbroic rocks within the reconnaissance sampling block, where copper-nickel mineralization was known to be associated with the olivine gabbros. Sites were located in the manner described above and duplicate samples were taken at a number of sites, as at Prairie Lake. A total of 124 'B' horizon soil and till samples were collected from the Killala Lake area.

Sample Preparation and Chemical Analysis

All sample material was shipped to the Geoscience Laboratories, Ontario Geological Survey, Toronto for preparation and chemical analysis. Soil and overburden samples were oven-dried at 80°C. Overburden samples were passed through a series of stainless-steel Tyler sieves containing 16, 60, and 250 mesh screens, whereas the 'B' horizon soil samples were only passed through an 80 mesh screen. The −80 mesh fraction of 'B' horizon soils, the −250 mesh fraction of tills, and the heavy mineral separate (using tetrabromethane, specific gravity 2.96) of the −60 +250 mesh fraction of tills were analyzed for

1) hot HNO_3-HCl extractable Cu, Zn, Pb, Ni, Co, Mn, and Cr by atomic absorption spectrophotometry;

2) Ba, Sr, Nb, La, Y, Zr, and Ti by DC arc emission spectrography (except that, because of the higher concentrations involved, titanium in the heavy mineral separate was determined by atomic absorption spectrophotometry and expressed as the oxide); and

3) Mo and P by colorimetric-gravimetric procedures.

Analytical Precision

Analytical precision is a measure of the reproducibility of chemical data and is used to assess the quality of the laboratory work. Following the procedure of Garrett (1969), duplicate analyses of selected samples were used to estimate the analytical precision of the project results. As several of the single element frequency distributions were positively skewed, analytical precision computations were carried out on both the original and $\log_{10}$ transformed data. The results for the Prairie Lake and Killala Lake samples are presented in Tables 1 and 2, respectively.

Data from elements whose calculated precision levels are greater than ±15 percent should be further evaluated prior to discarding them from subsequent geological interpretation. Where the majority of the results for a given element cluster at or near the detection limit of the analytical method employed, a range where precision is frequently poorer and where the percentage change in metal concentrations may be large, the computed precision value may be misleading. In such cases, no estimate of precision over the higher concentration ranges can be obtained for the data, and their use in interpretation is at the discretion of the geologist.

The following points can be made regarding the results of the precision computations (Tables 1 and 2) using duplicate analytical data collected as part of this investigation:

(1) All element/sample type combinations having calculated precisions within the ± 15 percent limit are considered to be sufficiently reproducible.

(2) Those elements determined by emission spectrography (Ba, Sr, Nb, La, Y, Zr and Ti) exhibit poorer precision than those analyzed by atomic absorption or colorimetric-gravimetric methods. This feature reflects the semi-quantitative nature of the spectrographic method used in this study. As the majority of the trace element frequency distributions are positively skewed, it is more appropriate to use precision values computed from the $\log_{10}$ transformed results. In this form, each data set more closely approximates the normal distribution upon which the statistical theory was based. After transformation, the semi-quantitative Ba, Sr, Zr, and Ti results obtained by emission spectrography fall within the acceptable analytical precision limit of ±15 percent at the 95 percent confidence level. Results for La and Y in the −250 mesh and heavy mineral fractions of till are similarly acceptable.

(3) Niobium results may not be sufficiently precise for geological interpretation purposes.

(4) Molybdenum is present in concentrations largely at or below the detection limit (1 ppm) of the analytical method employed. This distribution accounts for the poor precision values computed for the original results from all sample media, as explained above, and for the inability to compute the precision values for $\log_{10}$ transformed data.

Analytical precision constitutes only one part of geochemical data reliability analysis. A more complete assessment of the principal sources of data variability is presented in the Appendix.

TABLE 1 ANALYTICAL PRECISION OF GEOCHEMICAL DATA (EXPRESSED IN PERCENT) AT THE 95 PERCENT CONFIDENCE LEVEL[1]), PRAIRIE LAKE AREA.

	SAMPLE TYPE					
	'B' Horizon Soils		−250 Mesh Tills		Heavy Minerals	
ELEMENT	Original	Log$_{10}$ Transformed	Original	Log$_{10}$ Transformed	Original	Log$_{10}$ Transformed
Mn	3.3	0.4	3.3	0.7	1.6	0.2
Cu	7.8	2.4	5.4	2.1	5.3	1.9
Zn	2.5	0.5	8.2	0.8	4.5	0.7
Ni	5.4	2.3	6.1	1.9	5.3	1.7
Co	7.4	3.5	12.6	6.3	5.1	2.2
Pb	11.6	3.4	11.4	4.6	6.0	1.5
Cr	4.5	1.2	8.6	1.7	8.6	1.6
Ba	24.6	3.7	14.2	2.6	5.0	7.0
P	3.3	0.8	3.6	0.9	34.3	3.7
Sr	53.5	6.7	42.0	4.2	57.3	2.9
La	100.4	17.4	98.7	6.0	42.3	5.3
Y	45.1	20.5	57.4	13.0	79.1	7.4
Zr	55.7	8.4	29.0	5.3	24.4	4.21
Mo	43.2	N.C.[3]	107.7	N.C.[3]	N.C.[3]	N.C.[3]
Nb	385.5	15.5	53.6	13.4	57.1	205.4
Ti	19.6	2.8	21.4	2.8	6.6[4]	1.4[4]
N[2]	32	32	34	34	32	32

[1] After the procedure of Garrett (1969).

[2] N = number of pairs of duplicate analyses used in the computations.

[3] N.C. = not computed.

[4] Calculation based on analyses which are expressed as the oxide, in percent.

Data Processing

Field and laboratory results were transferred to 80 column computer cards for data listing and computer processing. Basic statistical parameters were computed for both original and log$_{10}$ transformed analytical results using a version of the GAS package by Willington (1973) adapted for use on the Ontario Government's IBM 370 computer. Analytical precision and analysis of variance calculations were done on a program written by Tom Pauk of the Geoservices Section, Ontario Geological Survey, Toronto and based on the models of Garrett (1969), Krumbein and Graybill (1965), and Scheffé (1959). Summaries of the statistical parameters for each element/sample type combination are given in Tables 3 to 14. Complete listings of the original data can be found in Appendices II to V in Ontario Geological Survey Open File Report 5257 (Closs and Sado 1979).

TABLE 2 ANALYTICAL PRECISION GEOCHEMICAL DATA, (EXPRESSED IN PERCENT, AT THE 95 PERCENT CONFIDENCE LEVEL[1]), KILLALA LAKE AREA.

	SAMPLE TYPE					
	'B' Horizon Soils		−250 Mesh Tills		Heavy Minerals	
ELEMENT	Original	Log_{10} Transformed	Original	Log_{10} Transformed	Original	Log_{10} Transformed
Mn	10.5	1.9	7.1	1.4	4.8	0.53
Cu	16.2	5.0	7.7	3.3	18.6	5.2
Zn	4.9	1.3	4.9	1.5	2.1	0.4
Ni	7.5	3.5	10.6	3.1	4.3	2.1
Co	22.8	8.9	14.3	8.4	5.4	2.4
Pb	15.0	4.8	23.7	7.6	8.4	3.9
Cr	5.4	1.4	5.5	1.4	4.2	0.7
Ba	21.6	4.2	16.0	3.8	12.3	N.C.
P	15.3	2.0	14.7	2.3	47.8	19.8
Sr	21.6	4.4	22.4	4.2	16.2	3.4
La	44.9	10.5	56.9	11.1	29.9	7.1
Y	53.4	26.3	31.3	12.8	51.4	9.6
Zr	55.7	11.3	54.3	9.4	15.1	4.0
Mo	117.0	N.C.[3]	58.3	N.C.[3]	N.C.[3]	N.C.[3]
Nb	128.5	25.4	73.1	15.6	47.2	123.6
TiO_2	30.8	3.6	19.5	2.6	2.7[4]	1.0[4]
N[2]	42	42	40	40	26	26

[1] After the procedure of Garrett (1969).

[2] N = number of pairs of duplicate analyses used in the computations.

[3] N.C. = not computed.

[4] Calculation based on analyses which are expressed as the oxide, in percent.

RESULTS

The results of this study are described under the following headings: Basic Data Statistics, Interpretational and Data Presentation Considerations, and Distribution of Metals in Overburden. The results are discussed in the final section of this report.

Basic Data Statistics

Geochemical surveys lead to the creation of large volumes of data. Basic statistical procedures provide means of summarizing and classifying these data sets. The range, arithmetic mean, and standard deviation for each element in each of the three sample media are summarized, by area, in Tables 3 to 14. Individual tables have been compiled for the reconnaissance and detailed survey results. As many of the histograms exhibited positive skewness, statistical parameters were also computed for $\log_{10}$ transformed data. The following general comments, arranged by area and sample type, can be made regarding the geochemical results obtained in this investigation.

PRAIRIE LAKE AREA

(1)'B' Horizon Soil (Tables 3 and 4)-Mean concentrations of Cu, Pb, Zr, and Mo are similar in both reconnaissance and detailed sample populations, whereas that of Ba is slightly lower in the data set from the detailed area. Also, mean concentrations of Ti and Sr are slightly higher in the detailed area sample population, while those of Mn, Zn, Ni, Co, Cr, P, La, Y, and Nb are 1.5 and 2 times higher.

(2) −250 Mesh Till Fraction (Tables 5 and 6)-Mean concentrations of Pb, Ti, and Ba are similar in both reconnaissance and detailed sample populations, while those of Mn, Cu, Zn, Ni, Co, Cr, P, Sr, La, Y, and Nb are higher in the data set from the detailed area.

(3) Heavy Mineral Separates of the −60 +250 Mesh Till Fraction (Tables 7 and 8)-Mean concentrations of Co, Pb, Zr, and Mo are lower, whereas those of Mn, Cu, Zn, Ni, Cr, Ba, P, Sr, La, Y, Nb, and TiO_2 are higher, in the detailed data set relative to the reconnaissance data set.

The differences in mean metal concentrations between the Prairie Lake reconnaissance and detailed sample populations reflect the higher proportion of both carbonatite bedrock and mineral occurrences in the detailed study area.

KILLALA LAKE AREA

(1)'B' Horizon Soil (Tables 9 and 10)-Mean concentrations of Mn, Pb and Y are similar in both sample populations, whereas those of Zn, Cr, Ba, La, Zr, Mo, Nb, and Ti are lower in samples from the detailed survey area. Mean Cu, Ni, Co, P, and Sr concentrations are higher in the data set from the detailed area.

(2) −250 Mesh Till Fraction (Tables 11 and 12)-Mean concentrations of Zn, Pb, P, Sr, and Y are similar in both reconnaissance and detailed sample populations, while those of Cr, La, Zr, Mo, Nb, and Ti are lower in the data set from the detailed area. Mean Mn, Cu, Ni, Co, and Ba concentrations are slightly higher in the detailed area sample population.

(3)Heavy Mineral Separates of the −60 +250 Mesh Till Fraction (Tables 13 and 14)-Mean concentrations of Mn, Ba, Y, and Mo are similar in both sample populations, whereas those of Zn, Pb, Cr, P, La, Zr, Nb, and TiO_2 are lower in the data set from the detailed survey area. Mean Cu, Ni, Co, and Sr concentrations are higher in the detailed area sample population.

The differences in mean metal concentrations between the Killala Lake reconnaissance and detailed sample populations reflect the higher proportion of gabbroic rock and associated copper-nickel mineralization in the detailed study area.

TABLE 3 | STATISTICAL PARAMETERS FOR RECONNAISSANCE 'B' HORIZON SOIL GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

PARAMETER	ELEMENT[1]							
	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	220 - 999(1)	6 - 95	23 - 800	9 - 247	3 - 68	16 - 80	11 - 580	140 - 1500
Arithmetic Mean ($\overline{X}$)	1807	29	165	42	13	28	107	456
Standard Deviation (S)	2511	21	169	55	14	10	114	220
$\overline{X} + 2S$	6829	71	503	152	41	48	335	896
Logarithmic Mean ($\overline{X}_L$)	2.892	1.375	2.204	1.407	0.932	1.421	1.883	2.626
Geometric Mean[3]	780	24	106	26	9	26	77	423
Standard Deviation (S_L)	0.550	0.283	0.411	0.377	0.398	0.130	0.323	0.161
$\overline{X}_L + 2S_L$[4]	3.992 (9830)	1.941 (87)	2.846 (702)	2.162 (145)	1.728 (54)	1.681 (48)	2.529 (337)	2.949 (889)

PARAMETER	ELEMENT[1]							
	P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	260 - 8000	80 - 1500	15 - 1000	5 - 300	100 - 1000	0.5 - 5	10 - 3000	3500 - 9999(13)
Arithmetic Mean ($\overline{X}$)	2854	362	104	28	435	0.6	357	7291
Standard Deviation (S)	2233	235	202	44	199	0.7	621	1968
$\overline{X} + 2S$	7311	832	508	116	833	2.0	1699	11227
Logarithmic Mean ($\overline{X}_L$)	3.280	2.497	1.563	1.228	2.583	1.739	1.862	3.846
Geometric Mean[3]	1900	314	37	17	383	0.548	73	7015
Standard Deviation (S_L)	0.423	0.224	0.565	0.407	0.240	0.171	0.824	0.123
$\overline{X}_L + 2S_L$[4]	4.125 (13350)	2.945 (880)	2.694 (494)	2.042 (110)	3.063 (1150)	0.081 (1.20)	3.510 (3235)	4.091 (12330)

Number of samples (N) = 48.

[1] Metal comcentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999 ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Atilogarithms in brackets.

TABLE 4 STATISTICAL PARAMETERS FOR 'B' HORIZON SOIL GEOCHEMICAL DATA, PRAIRIE LAKE DETAILED AREA.

PARAMETER	ELEMENT[1]							
	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	240 - 9999(1)	11 - 104	45 - 1020	9 - 334	3 - 68	10 - 108	11 - 580	104 - 860
Arithmetic Mean ($\overline{X}$)	3386	31	388	68	24	29	162	390
Standard Deviation (S)	2678	17	274	64	17	14	152	136
$\overline{X} + 2S$	8742	65	936	196	58	57	466	662
Logarithmic Mean ($\overline{X}_L$)	3.301	1.437	2.449	1.642	1.242	1.424	2.009	2.565
Geometric Mean[3]	2002	27	281	44	17	27	100	368
Standard Deviation (S_L)	0.525	0.212	0.383	0.418	0.388	0.158	0.439	0.154
$\overline{X}_L + 2S_L$[4]	4.351	1.861	3.215	2.478	2.018	1.740	2.887	2.874
	(22501)	(73)	(1639)	(300)	(104)	(55)	(770)	(748)

PARAMETER	ELEMENT[1]							
	P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	600 - 9999(18)	100 - 2500	15 - 2500	5 - 1500	100 - 1000	0.5 - 3.0	10 - 3000	4000 - 9999(36)
Arithmetic Mean ($\overline{X}$)	5440	424	185	52	463	0.63	598	8250
Standard Deviation (S)	3248	300	336	173	180	0.43	683	2003
$\overline{X} + 2S$	11936	1024	857	398	823	1.49	1964	12256
Logarithmic Mean ($\overline{X}_L$)	3.634	2.569	1.871	1.430	2.632	1.752	2.421	3.901
Geometric Mean[3]	4305	370	74	27	428	0.56	263	7967
Standard Deviation (S_L)	0.327	0.210	0.602	0.365	0.178	0.162	0.627	0.121
$\overline{X}_L + 2S_L$[4]	4.288	2.989	3.075	2.160	2.988	0.076	3.674	4.143
	(19373)	(973)	(1186)	(145)	(972)	(1.19)	(4799)	(13880)

Number of Samples (N) = 72.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithim of $\overline{X}_L$.

[4] Antilogarithim in brackets.

TABLE 5 STATISTICAL PARAMETERS FOR RECONNAISSANCE –250 MESH TILL FRACTION GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

	ELEMENT[1]							
PARAMETER	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	240 - 5300	6 - 174	22 - 920	13 - 440	3 - 78	12 - 110	15 - 293	220 - 590
Arithmetic Mean ($\overline{X}$)	1369	33	170	65	19	26	81	348
Standard Deviation (S)	1455	37	217	60	19	15	54	84
$\overline{X} + 2S$	4279	107	604	185	57	57	189	516
Logarithmic Mean ($\overline{X}_L$)	2.938	1.329	1.958	1.565	1.087	1.366	1.836	2.531
Geometric Mean[3]	867	21	91	37	12	23	68	339
Standard Deviation (S_L)	0.397	0.370	0.462	0.402	0.398	0.174	0.247	0.100
$\overline{X}_L + 2S_L$[4]	3.732 (5395)	2.070 (117)	2.882 (763)	2.370 (234)	1.882 (76)	1.714 (52)	2.330 (214)	2.731 (537)

	ELEMENT[1]							
PARAMETER	P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	160 - 9999(8)	200 - 1000	15 - 300	5 - 80	150 - 1500	0.5 - 1	10 - 1500	3500 - 9999(4)
Arithmetic Mean ($\overline{X}$)	3313	329	72	26	492	0.5	157	7077
Standard Deviation (S)	3529	152	68	13	213	0.1	265	1615
$\overline{X} + 2S$	10371	633	208	52	918	0.7	687	10307
Logarithmic Mean ($\overline{X}_L$)	3.263	2.487	1.649	1.364	2.661	1.716	1.770	3.837
Geometric Mean[3]	1830	307	45	23	458	0.521	59	6874
Standard Deviation (S_L)	0.483	0.152	0.450	0.212	0.170	0.071	0.624	0.110
$\overline{X}_L + 2S_L$[4]	4.228 (16900)	2.792 (619)	2.549 (354)	1.788 (61)	3.001 (1001)	1.858 (0.721)	3.018 (1043)	4.056 (11386)

Number of samples (N) = 52

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithm in brackets.

TABLE 6 | STATISTICAL PARAMETERS FOR –250 MESH TILL FRACTION GEOCHEMICAL DATA, PRAIRIE LAKE DETAILED AREA.

PARAMETER	ELEMENT[1] Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	350 - 9000	8 - 170	30 - 1300	10 - 405	3 - 68	5 - 86	9 - 440	80 -650
Arithmetic Mean ($\overline{X}$)	2445	49	353	110	26	26	103	319
Standard Deviation (S)	2076	43	343	115	19	15	87	126
$\overline{X}$ + 2S	6597	135	1039	340	64	56	277	571
Logarithmic Mean ($\overline{X}_L$)	3.196	1.519	2.286	1.793	1.279	1.344	1.881	2.465
Geometric Mean[3]	1571	33	193	62	19	22	76	291
Standard Deviation (S_L)	0.436	0.389	0.513	0.481	0.369	0.235	0.348	0.197
$\overline{X}_L + 2S_L$[4]	4.068	2.297	3.312	2.755	2.017	1.814	2.577	2.859
	(11692)	(128)	(3051)	(570)	(104)	(65)	(378)	(723)

PARAMETER	ELEMENT[1] P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	400 - 9999(14)	30 - 2000	15 - 1500	5 - 150	80 - 1000	0.5 - 2.0	10 - 5000	3000 - 9999(22)
Arithmetic Mean ($\overline{X}$)	4942	468	145	37	444	0.53	493	7722
Standard Deviation (S)	3495	349	189	24	171	0.18	789	1979
$\overline{X}$ + 2S	11932	1166	513	85	786	0.89	2071	11680
Logarithmic Mean ($\overline{X}_L$)	3.537	2.593	1.989	1.500	2.612	1.712	2.322	3.871
Geometric Mean[3]	3441	391	97	32	409	0.52	210	7428
Standard Deviation (S_L)	0.414	0.254	0.390	0.252	0.187	0.079	0.598	0.128
$\overline{X}_L + 2S_L$[4]	4.364	3.101	2.769	2.004	2.986	1.870	3.518	4.127
	(23136)	(1262)	(586)	(101)	(974)	(0.74)	(3292)	(13381)

Number of samples (N) = 72

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithms in brackets.

TABLE 7 STATISTICAL PARAMETERS FOR RECONNAISSANCE GEOCHEMICAL DATA FROM HEAVY MINERAL SEPARATES OF THE −60 +250 MESH TILL FRACTION, PRAIRIE LAKE AREA.

PARAMETER	ELEMENT[1] Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	2440 - 9999(4)	10 - 106	128 - 1980	8 - 305	12 - 74	22 - 660	12 - 1280	80 - 730
Arithmetic Mean ($\overline{X}$)	4818	30	249	93	33	96	378	217
Standard Deviation (S)	1963	22	258	65	13	107	239	137
$\overline{X} + 2S$	8784	74	765	223	59	310	856	491
Logarithmic Mean ($\overline{X}_L$)	3.652	1.392	2.327	1.851	1.477	1.828	2.423	2.272
Geometric Mean[3]	4488	25	212	71	30	67	265	187
Standard Deviation (S_L)	0.159	0.258	0.195	0.355	0.187	0.335	0.466	0.228
$\overline{X}_L + 2S_L$[4]	3.970 (9330)	1.908 (81)	2.716 (521)	2.562 (365)	1.852 (71)	2.498 (315)	3.355 (2264)	2.728 (534)

PARAMETER	ELEMENT[1] P[5]	Sr	La	Y	Zr	Mo	Nb	TiO_2[5,6]
Range[2]	18 - 1160	100 - 5000	70 - 1500	20 - 300	50 - 9999(1)	0.5 - 9	25 - 3000	0 - 1290
Arithmetic Mean ($\overline{X}$)	233	877	331	89	904	1.8	439	375
Standard Deviation (S)	240	1063	278	58	1319	1.5	648	312
$\overline{X} + 2S$	713	3003	887	205	3542	4.8	1735	999
Logarithmic Mean ($\overline{X}_L$)	2.149	2.698	2.396	1.882	2.803	0.073	2.245	2.495
Geometric Mean[3]	141	499	249	76	635	1.18	176	313
Standard Deviation (S_L)	0.451	0.445	0.326	0.230	0.362	0.271	0.594	0.292
$\overline{X}_L + 2S_L$[4]	3.052 (1134)	3.588 (3870)	3.047 (1115)	2.343 (220)	3.527 (3368)	0.615 (4.118)	3.433 (2713)	3.080 (1202)

Number of samples (N) = 52

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999 ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithm in brackets.

[5] Metal concentration expressed as percent x 100.

[6] For calculation of logarithmic mean, geometric mean, standard deviation and $\overline{X}_L + 2S_L$, N = 50 for this element.

TABLE 8 STATISTICAL PARAMETERS FOR GEOCHEMICAL DATA FROM HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, PRAIRIE LAKE DETAILED AREA.

	ELEMENT[1]							
PARAMETER	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	2040 - 9999(20)	10 - 165	128 - 1540	11 - 328	6 - 74	28 - 223	15 - 1640	60 - 950
Arithmetic Mean ($\overline{X}$)	6255	41	396	108	31	76	475	254
Standard Deviation (S)	2714	33	302	84	16	41	415	159
$\overline{X} + 2S$	11683	107	1000	276	63	158	1305	572
Logarithmic Mean ($\overline{X}_L$)	3.755	1.499	2.501	1.872	1.435	1.829	2.432	2.330
Geometric Mean[3]	5682	31	317	75	27	67	270	214
Standard Deviation (S_L)	0.193	0.303	0.277	0.414	0.240	0.206	0.553	0.256
$\overline{X}_L + 2S_L$[4]	4.140 (14070)	2.105 (128)	3.055 (1134)	2.700 (501)	1.914 (82)	2.241 (174)	3.538 (3440)	2.842 (695)

	ELEMENT[1]							
PARAMETER	P[5]	Sr	La	Y	Zr	Mo	Nb	TiO_2[5]
Range[2]	15 - 1300	10 - 5000	15 - 5000	10 - 1000	50 - 2000	0.5 - 4.0	45 - 5000	60 - 1610
Arithmetic Mean ($\overline{X}$)	341	1223	584	123	607	1.56	738	518
Standard Deviation (S)	252	1091	883	136	319	1.45	874	378
$\overline{X} + 2S$	845	3405	2350	395	1245	4.46	2486	1274
Logarithmic Mean ($\overline{X}_L$)	2.412	2.908	2.583	1.961	2.716	0.098	2.617	2.583
Geometric Mean[3]	258	809	382	91	521	1.25	415	383
Standard Deviation (S_L)	0.348	0.439	0.363	0.314	0.264	0.288	0.478	0.356
$\overline{X}_L + 2S_L$[4]	3.108 (1283)	3.786 (6118)	3.309 (3037)	2.589 (387)	3.244 (1756)	0.674 (4.72)	3.573 (3755)	3.295 (1972)

Number of samples(N) = 72.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithms in brackets.

[5] Metal concentration espressed as percent x 100.

TABLE 9 | STATISTICAL PARAMETERS FOR RECONNAISSANCE 'B' HORIZON SOIL GEOCHEMICAL DATA, KILLALA LAKE AREA.

	ELEMENT[1]							
PARAMETER	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	117 - 1930	12 - 216	24 - 218	13 - 200	3 - 92	12 - 48	24 - 414	140 - 480
Arithmetic Mean ($\overline{X}$)	410	45	63	39	14	25	78	295
Standard Deviation (S)	344	39	43	32	16	7	65	82
$\overline{X}$ + 2S	1098	123	149	103	46	39	208	459
Logarithmic Mean ($\overline{X}_L$)	2.517	1.536	1.722	1.502	0.987	1.382	1.817	2.451
Geometric Mean[3]	329	34	53	32	10	24	66	283
Standard Deviation (S_L)	0.263	0.304	0.256	0.248	0.363	0.119	0.227	0.130
$\overline{X}_L + 2S_L$[4]	3.044	2.145	2.234	1.998	1.714	1.619	2.270	2.711
	(1175)	(140)	(172)	(100)	(52)	(42)	(186)	(515)

	ELEMENT[1]							
PARAMETER	P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	50 - 9999(3)	10 - 500	15 - 100	5 - 25	80 - 700	0.5 - 5	10 - 150	3500 - 9999(1)
Arithmetic Mean ($\overline{X}$)	1522	217	29	11	280	0.99	19	6149
Standard Deviation (S)	2501	72	21	6	137	1.0	31	1356
$\overline{X}$ + 2S	6524	361	71	23	554	2.9	81	8861
Logarithmic Mean ($\overline{X}_L$)	2.865	2.300	1.370	0.981	2.395	1.811	1.105	3.778
Geometric Mean[3]	733	200	23	10	249	0.65	13	5997
Standard Deviation (S_L)	0.474	0.230	0.270	0.248	0.221	0.262	0.299	0.099
$\overline{X}_L + 2S_L$[4]	3.184	2.760	1.909	1.476	2.838	0.335	1.704	3.977
	(6517)	(576)	(85)	(30)	(688)	(2.17)	(51)	(9478)

Number of samples(N) = 47.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithms in brackets.

TABLE 10 | STATISTICAL PARAMETERS FOR 'B' HORIZON SOIL GEOCHEMICAL DATA, KILLALA LAKE DETAILED AREA.

	ELEMENT[1]							
PARAMETER	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	190 - 1270	8 - 500	24 - 178	17 - 311	3 - 66	16 - 43	25 - 267	120 - 440
Arithmetic Mean ($\overline{X}$)	405	61	54	55	17	23	66	281
Standard Deviation (S)	226	90	33	63	15	5	37	87
$\overline{X}$ + 2S	857	241	120	181	47	33	140	455
Logarithmic Mean ($\overline{X}_L$)	2.559	1.533	1.682	1.603	1.093	1.342	1.786	2.425
Geometric Mean[3]	362	34	48	40	12	22	61	266
Standard Deviation (S_L)	0.194	0.435	0.202	0.308	0.372	0.095	0.153	0.147
$\overline{X}_L + 2S_L$[4]	2.947	2.403	2.086	2.219	1.837	1.532	2.092	2.719
	(885)	(253)	(122)	(170)	(69)	(34)	(123)	(525)

	ELEMENT[1]							
PARAMETER	P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	300 - 9999(2)	10 - 500	15 - 45	5 - 20	80 - 700	0.5 - 3.0	10 - 150	2500 - 8000
Arithmetic Mean ($\overline{X}$)	1633	234	18	11	245	0.65	14	5514
Standard Deviation (S)	2284	68	9	5	110	0.49	23	1648
$\overline{X}$ + 2S	6201	370	36	21	465	1.63	60	8810
Logarithmic Mean ($\overline{X}_L$)	2.978	2.332	1.225	0.969	2.350	1.762	1.033	3.721
Geometric Mean[3]	951	215	17	9	224	0.60	11	5254
Standard Deviation (S_L)	0.406	0.245	0.140	0.226	0.191	0.177	0.196	0.140
$\overline{X}_L + 2S_L$[4]	3.790	2.822	1.505	1.421	2.731	0.116	1.425	4.001
	(6163)	(663)	(32)	(26)	(539)	(1.31)	(27)	(10009)

Number of samples(N) = 36.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithms in brackets.

TABLE 11 | STATISTICAL PARAMETERS FOR RECONNAISSANCE −250 MESH TILL FRACTION GEOCHEMICAL DATA, KILLALA LAKE AREA.

PARAMETER	ELEMENT[1] Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	182 - 1870	8 - 470	21 - 136	13 - 186	3 - 54	13 - 29	33 - 460	140 - 420
Arithmetic Mean ($\overline{X}$)	432	56	44	45	15	20	66	254
Standard Deviation (S)	257	86	22	40	13	4	60	54
$\overline{X}$ + 2S	946	228	88	125	41	28	186	362
Logarithmic Mean ($\overline{X}_L$)	2.591	1.469	1.607	1.535	1.059	1.289	1.762	2.395
Geometric Mean[3]	390	29	40	34	11	19	58	248
Standard Deviation (S_L)	0.183	0.447	0.177	0.300	0.331	0.088	0.180	0.095
$\overline{X}_L + 2S_L$[4]	2.956	2.363	1.961	2.135	1.721	1.465	2.122	2.585
	(904)	(231)	(91)	(137)	(53)	(29)	(132)	(384)

PARAMETER	ELEMENT[1] P	Sr	La	Y	Zr	Mo	Nb	Ti
Range[2]	200 - 4000	150 - 300	15 - 150	5 - 40	150 - 800	0.5 - 3	10 - 200	2500 - 9000
Arithmetic Mean ($\overline{X}$)	1183	251	25	17	419	0.6	19	6531
Standard Deviation (S)	893	47	28	6	144	0.5	31	1863
$\overline{X}$ + 2S	2969	345	81	29	707	1.6	81	10257
Logarithmic Mean ($\overline{X}_L$)	2.977	2.391	1.274	1.206	2.595	1.750	1.107	3.793
Geometric Mean[3]	993	246	188	16	395	0.56	13	6210
Standard Deviation (S_L)	0.286	0.093	0.266	0.147	0.155	0.170	0.195	0.147
$\overline{X}_L + 2S_L$[4]	3.550	2.577	1.806	1.501	2.907	0.090	1.697	4.087
	(355)	(377)	(64)	(32)	(806)	(1.23)	(50)	(1220)

Number of samples(N) = 48.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogartihms of $\overline{X}_L$.

[4] Antilogarithm in brackets.

TABLE 12 | STATISTICAL PARAMETERS FOR −250 MESH TILL FRACTION GEOCHEMICAL DATA, KILLALA LAKE DETAILED AREA.

PARAMETER	ELEMENT[1]							
	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	250 - 740	8 - 470	17 - 89	14 - 220	3 - 64	11 - 28	28 - 80	120 - 550
Arithmetic Mean ($\overline{X}$)	443	73	41	55	18	19	54	279
Standard Deviation (S)	99	98	14	53	16	4	11	95
$\overline{X}$ + 2S	641	269	69	161	50	27	76	469
Logarithmic Mean ($\overline{X}_L$)	2.635	1.597	1.591	1.587	1.081	1.264	1.723	2.423
Geometric Mean[3]	431	39	39	39	12	19	53	265
Standard Deviation (S_L)	0.100	0.453	0.142	0.354	0.418	0.094	0.094	0.143
$\overline{X}_L + 2S_L$[4]	2.835	2.503	1.875	2.295	1.917	1.452	1.911	2.709
	(683)	(318)	(75)	(197)	(83)	(28)	(82)	(512)

PARAMETER	ELEMENT[1]							
	P	Sr	La	Y	Zr	Mo	Nb	TiO_2
Range[2]	200 - 4000	100 - 300	15 - 100	5 - 25	100 - 800	0.5 - 1.0	10 - 70	2000 - 9000
Arithmetic Mean ($\overline{X}$)	1242	237	18	15	318	0.51	14	5361
Standard Deviation (S)	948	51	15	5	143	0.08	13	2005
$\overline{X}$ + 2S	3138	339	48	25	604	0.67	40	9371
Logarithmic Mean ($\overline{X}_L$)	2.987	2.365	1.214	1.161	2.459	1.707	1.061	3.696
Geometric Mean[3]	971	231	16	14	288	0.51	11	4966
Standard Deviation (S_L)	0.308	0.104	0.161	0.161	0.202	0.050	0.207	0.177
$\overline{X}_L + 2S_L$[4]	3.603	2.573	1.536	1.483	2.863	1.807	1.475	4.050
	(4001)	(373)	(34)	(30)	(730)	(0.64)	(30)	(11220)

Number of samples(N) = 36.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithm in brackets.

TABLE 13 STATISTICAL PARAMETERS FOR RECONNAISSANCE GEOCHEMICAL DATA FROM HEAVY MINERAL SEPARATES OF THE −60 +250 MESH TILL FRACTION, KILLALA LAKE AREA.

PARAMETER	ELEMENT[1]							
	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	1820 - 7820	8 - 220	109 - 400	11 - 180	8 - 117	21 - 382	13 - 940	50 - 280
Arithmetic Mean ($\overline{X}$)	3654	39	191	89	43	105	351	106
Standard Deviation (S)	1282	42	60	37	20	95	173	40
$\overline{X}$ + 2S	6218	123	311	163	83	295	697	186
Logarithmic Mean ($\overline{X}_L$)	3.540	1.424	2.262	1.889	1.592	1.853	2.433	2.002
Geometric Mean[3]	3465	27	183	77	39	71	271	101
Standard Deviation (S_L)	0.140	0.353	0.121	0.271	0.205	0.384	0.417	0.135
$\overline{X}_L + 2S_L$[4]	3.819	2.129	2.505	2.432	2.003	2.621	3.270	2.273
	(6591)	(1343)	(320)	(264)	(101)	(418)	(1861)	(187)

PARAMETER	ELEMENT[1]							
	P[5]	Sr	La	Y	Zr	Mo	Nb	TiO_2[5]
Range[2]	4 - 640	5 - 200	45 - 400	30 - 70	45 - 2000	0.5 - 4	10 - 200	120 - 360
Arithmetic Mean ($\overline{X}$)	247	118	137	57	680	1.7	67	247
Standard Deviation (S)	53	64	58	11	424	1.1	44	53
$\overline{X}$ + 2S	353	246	253	79	1528	3.9	155	353
Logarithmic Mean ($\overline{X}_L$)	1.823	1.928	2.109	1.745	2.726	0.142	1.716	2.382
Geometric Mean[3]	67	85	129	56	532	1.10	52	241
Standard Deviation (S_L)	0.493	0.4750	0.160	0.092	0.349	0.308	0.352	0.105
$\overline{X}_L + 2S_L$[4]	2.808	2.878	2.430	1.930	3.423	0.758	2.419	2.592
	(643)	(755)	(269)	(85)	(2651)	(5.74)	(262)	(391)

Number of samples(N) = 47.

[1] Metal concentrations expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithms in brackets.

[5] Metal concentration expressed as percent x 100.

TABLE 14 STATISTICAL PARAMETERS FOR GEOCHEMICAL DATA FROM HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, KILLALA LAKE DETAILED AREA.

PARAMETER	ELEMENT[1]							
	Mn	Cu	Zn	Ni	Co	Pb	Cr	Ba
Range[2]	1820 - 7820	12 - 255	112 - 400	13 - 194	18 - 95	15 - 283	13 - 566	50 - 230
Artihmetic Mean ($\overline{X}$)	3419	59	179	103	49	87	330	108
Standard Deviation (S)	1028	61	51	39	18	81	123	30
$\overline{X}$ + 2S	5475	181	281	181	85	249	576	168
Logarithmic Mean ($\overline{X}_L$)	3.517	1.585	2.238	1.972	1.665	1.747	2.454	2.019
Geometric Mean[3]	3291	38	173	94	46	56	284	104
Standard Deviation (S_L)	0.119	0.387	0.109	0.210	0.159	0.415	0.319	0.113
$\overline{X}_L + 2S_L$[4]	3.756 (5704)	2.359 (228)	2.457 (287)	2.392 (247)	1.983 (96)	2.577 (377)	3.092 (1231)	2.245 (175)

PARAMETER	ELEMENT[1]							
	P[5]	Sr	La	Y	Zr	Mo	Nb	TiO_2[5]
Range[2]	5 - 600	5 - 200	80 - 250	30 - 70	100 - 1500	0.5 - 4.0	10 - 200	35 - 310
Arithmetic Mean ($\overline{X}$)	140	153	120	54	536	1.58	60	220
Standard Deviation (S)	127	55	34	11	310	1.15	39	71
$\overline{X}$ + 2S	394	263	188	76	1156	3.88	138	362
Logarithmic Mean ($\overline{X}_L$)	1.963	2.129	2.067	1.726	2.650	0.088	1.687	2.309
Geometric Mean[3]	92	135	117	53	447	1.22	49	200
Standard Deviation (S_L)	0.438	0.300	0.109	0.094	0.283	0.335	0.306	0.227
$\overline{X}_L + 2S_L$[4]	2.839 (690)	2.729 (536)	2.285 (193)	1.914 (82)	3.216 (1647)	0.758 (5.74)	2.299 (199)	2.763 (571)

Number of samples(N) = 32

[1] Metal concentraitons expressed in ppm unless otherwise noted.

[2] A numeral in brackets refers to the number of samples exceeding 9999ppm.

[3] Antilogarithm of $\overline{X}_L$.

[4] Antilogarithm in brackets.

[5] Metal concentration expressed as percent x 100.

Interpretational and Data Presentation Considerations

This geochemical program was a pilot or orientation study. A number of different types of overburden material were collected and/or isolated, and the concentrations of a wide range of potentially useful pathfinder elements (Boyle 1974) analytically determined for each sample type. The next stage was to assess these results and determine which sample type/trace element combinations are most useful in the mapping of carbonatites and alkalic complexes.

In this study, two separate areas were sampled, on both reconnaissance and detailed levels, and three overburden sample types were obtained and analyzed for 16 different chemical constituents. A systematic approach must be adopted because of the large number of single element maps (2x2x3x16 = 192) that can be generated from this data. The method of data evaluation employed in this study can be divided into three stages: (1) a consideration of the analytical reliability of the chemical data; (2) a consideration of the "stability" of the resultant geochemical maps; and (3) examination of the relationship of the geochemical maps to known geological features of the area. The first two stages, which permit a more informed selection of parameters to be considered in the third stage, are described and synthesized below. The results have been used in the selection of sample type/trace element combinations to be presented in map form in the next section.

The first stage in the data evaluation process is the calculation of analytical precision, which is a measure of the reproducibility of the geochemical results. Precision estimates computed on $\log_{10}$ transformed data are considered more appropriate since the histograms for most elements are positively skewed. The results have been grouped, in order of increasing variability, into the following classes: (1) precision less than ±15 percent (classification a.1, Tables 15 and 16); (2) precision ranging from ±15 to ±25 percent (classification a.2, Tables 15 and 16); and (3) precision greater than ±25 percent (classification a.3, Tables 15 and 16). In general, the more precise the analytical data, the better.

The "stability" of a map refers to its reproducibility upon repeat sampling and analysis. In this investigation, stability has been evaluated utilizing two results from the analysis of variance described in the Appendix. The first consideration is whether or not there is a significant partitioning of the sampling and regional components of total variance. Without a significant partitioning of these sources of variation, it would not be possible to decide if the differences in metal content portrayed on a geochemical map were due to local or regional effects, and the stability of the map would be suspect. Evaluation of this factor is based on whether a statistically significant partitioning of sampling and regional variance does or does not exist (classifications b.1 and b.2, respectively, Tables 15 and 16), based on the F ratio test (Davis 1973).

Having established that a signficant partitioning of these two sources of variance does exist, for a given element, it is then necessary to compare their relative magnitudes. Intuitively, those metals having the greatest proportion of their total variation resident in the regional component will be most useful for mapping regional geological features. In this investigation, an arbitrary cut-off of 50 percent has been adopted. Parameters having less than 50 percent

TABLE 15 | SYNTHESIS OF DATA EVALUATION, PRAIRIE LAKE AREA.

	SAMPLE TYPE					
	'B' HORIZON SOILS		−250 MESH TILLS		HEAVY MINERALS	
ELEMENT	Original	Log_{10} Transformed	Original	Log_{10} Transformed	Original	Log_{10} Transformed
Mn	111	111	112	111	111	111
Cu	122	122	122	122	122	122
Zn	111	111	111	111	111	111
Ni	111	111	122	112	112	111
Co	111	111	122	112	122	122
Pb	111	111	122	122	112	112
Cr	122	111	122	111	111	111
Ba	222	122	122	122	111	111
P	111	111	111	111	311	111
Sr	311	111	312	111	311	111
La	311	211	311	111	312	111
Y	311	211	311	111	311	111
Zr	312	112	322	122	211	111
Mo	322	−22	322	−22	322	322
Nb	322	211	311	111	312	322
Ti/TiO_2	211	111	211	111	111	122

KEY
a b c

a. Analytical Precision
1 = 0 to 15 percent
2 = 15 to 25 percent
3 = greater than 25 percent

b. Significance of Regional/Sampling Variance Partitioning (Based on F ratio test)
1 = Yes
2 = No

c. Percentage of Data Variance in Regional Component
1 = greater than 50 percent
2 = less than 50 percent

of their total variance accounted for by the regional component are not considered acceptable for geochemical mapping (classification c.2, Tables 15 and 16). Those metals whose regional variance component constitutes greater than 50 percent of the total are recommended for geochemical mapping (classification c.1, Tables 15 and 16).

The three components of geochemical data evaluation described above are synthesized, by area and sample type, in Tables 15 and 16. These tabulated results form the basis for the selection of geochemical parameters used in the map presentation and discussion in the next section. In order to assess the usefulness of each of the "acceptable" parameters identified through the procedure described above, it is necessary to examine the relationship between the patterns on each geochemical map and the known geological features in the area. This, the third stage in the data evaluation process, is dealt with in the next section.

TABLE 16 | SYNTHESIS OF DATA EVALUATION, KILLALA LAKE AREA

ELEMENT	SAMPLE TYPE 'B' HORIZON SOILS Original	 'B' HORIZON SOILS Log_{10} Transformed	 –250 MESH TILLS Original	 –250 MESH TILLS Log_{10} Transformed	 HEAVY MINERALS Original	 HEAVY MINERALS Log_{10} Transformed
Mn	111	111	111	111	111	111
Cu	211	111	111	111	211	111
Zn	111	111	111	111	111	111
Ni	111	111	112	111	111	111
Co	211	111	111	111	111	111
Pb	112	122	212	112	122	122
Cr	111	111	111	111	111	111
Ba	211	111	211	111	121	121
P	211	111	111	111	312	211
Sr	222	122	211	111	222	112
La	311	111	322	122	312	112
Y	311	311	312	112	311	111
Zr	312	112	312	112	221	121
Mo	311	–11	312	–12	311	311
Nb	312	312	311	211	311	311
Ti/TiO_2	311	111	211	111	111	111

KEY
a b c

a. Analytical Precision
1 = 0 to 15 percent
2 = 15 to 25 percent
3 = greater than 25 percent

b. Significance of Regional/Sampling Variance Partitioning (Based on F ratio test)
1 = Yes
2 = No

c. Percentage of Data Variance in Regional Component
1 = greater than 50 percent
2 = less than 50 percent

The classification of the geochemical data for each parameter into five groups (see geochemical maps, Charts A to D, back pocket) was done to facilitate symbolic map presentation of the results. The subdivisions are based upon an assessment of the form of individual histograms.

Distribution of Metals in Overburden

The distribution patterns of metals (Charts A to D, back pocket) in the three overburden sample types collected are described in this section. The 'B' soil horizon is most commonly sampled during routine exploration geochemistry surveys conducted in Ontario; this material was collected to permit comparison of results from other overburden sample types with those from a standard survey method.

In areas of deeper overburden, till covers the bedrock; elsewhere, an immature residual soil has developed from the weathering of near-surface carbonatitic or alkalic rocks. The occurrence of clasts of local rock types near the base of ablation till suggests a possible mixing of ablation and basal till-residual soil facies.

Metals may be dispersed mechanically and/or chemically in the overburden. To establish appropriate follow-up procedures, it is necessary to identify the mode(s) of transport of the metals in overburden. The −250 mesh fraction of till (i.e. silt- and clay-sized material) was isolated in order to investigate adsorbed metal, most likely related to hydromorphic processes. Metal held in fine particulate form due to weathering and/or glacial comminution cannot be excluded as another possible mode of occurrence in this sample type. The heavy mineral separate of the −60 +250 mesh fraction of till was isolated in order to investigate that component of trace elements in overburden related to physical transport.

The selection of sample type/trace element combinations for map presentation is based on the synthesis of data evaluation in the previous section (Tables 15 and 16). The histograms employed to classify the data are included with their respective geochemical maps (Charts A to D, back pocket). If the reader wishes to examine any parameter not presented in map form, all of the field observations and analytical results, together with sample location maps, are included as Appendices II to VI in Ontario Geological Survey Open File Report 5257 (Closs and Sado 1979).

PRAIRIE LAKE AREA

The distributions of Zn, Ni, Ti/TiO_2, Mn, Nb, La, Sr, Y and P are presented as geochemical maps for this area (Charts A-1 and A-2, back pocket). The bedrock geology map is included on both charts as Figure 15.

Zinc

Zinc concentrations in 'B' horizon soils can be divided into at least two groups with a break at the 100 ppm level (Figure 5, Chart A-1, back pocket). Samples containing less than 100 ppm Zn are coincident with ijolitic and granitic rocks whereas, those with values greater than this threshold generally overlie carbonatitic bedrock.

Zinc concentrations in the −250 mesh till fraction display three peaks on the histogram (Figure 6, Chart A-1, back pocket). Samples containing less than 80 ppm Zn generally overlie ijolitic and granitic rocks, those containing 80 to 120 ppm are found on the periphery of the complex, and those with greater than 120 ppm are commonly coincident with carbonatitic bedrock.

Zinc concentrations in the heavy mineral separates of till samples can be divided into three groups using the 200 and 300 ppm levels as boundaries (Figure 7, Chart A-1, back pocket). Samples containing less than 200 ppm Zn are concentrated along the periphery of the complex, those containing 200 to 300 ppm are generally situated near contacts between carbonatite and ijolite rock units, and those with greater than 300 ppm are largely coincident with carbonatite.

Zinc in all overburden sample types reflects the distribution of the two major bedrock units in the complex, with results from the heavy mineral separates being most specific.

Nickel

Nickel contents of most 'B' horizon soils are less than 30 ppm (Figure 8, Chart A-1, back pocket). Sample locations with higher Ni concentrations are generally located near carbonatite-ijolite contacts. Two samples containing greater than 80 ppm Ni come from the extreme north end of the grid where granitic bedrock has been mapped.

Nickel contents of – 250 mesh till samples are generally higher than those of 'B' horizon soils. Samples containing greater than 40 ppm Ni are located on the periphery of the complex (Figure 9, Chart A-1, back pocket), as was the case with the soils.

Nickel concentrations in the heavy mineral separates of till samples can be divided into three groups: (1) less than 40 ppm, corresponding to ijolitic bedrock; (2) 40 to 160 ppm, situated on the periphery of the complex; and (3) greater than 160 ppm, located south of Anomaly Lake over carbonatite and at the north end of the grid over granitic rocks (Figure 10, Chart A-1, back pocket).

The distribution of Ni in all sample media reflects the distribution of the major bedrock units in the complex.

Titanium

Titanium in 'B' horizon soils and – 250 mesh tills was determined by DC arc emission spectrography and expressed as the metal. Titanium in the heavy mineral separates of till samples was determined by atomic absorption spectrophotometry and expressed as the oxide because of its higher concentration in this sample medium.

Titanium concentrations in 'B' horizon soils can be divided into two groups at the 1.0 percent level (Figure 11, Chart A-1, back pocket). Sites containing greater than 1.0 percent Ti are generally coincident with carbonatitic rocks or the carbonatite-ijolite contact. Several stations at the northern and northeastern extremities of the grid, underlain by granitic rocks, also contain greater than 1.0 percent Ti. Samples from sites overlying ijolitic rocks contain 0.4 to 0.8 percent Ti.

Titanium concentrations in – 250 mesh till samples are similar to those of 'B' horizon soils, with fewer sites containing greater than 1.0 percent Ti (Figure

12, Chart A-1, back pocket).

Titania contents of the heavy mineral separates of till samples can be divided into two classes at the 5.0 percent level (Figure 13, Chart A-1,back pocket). Sites having TiO_2 concentrations greater than 5.0 percent are located over carbonatitic rocks. The geochemical map is similar to that of Ti in 'B' horizon soils.

The distribution of this element in all sample types reflects the distribution of the major bedrock units in the complex.

Manganese

Only the results for Mn in the heavy mineral separates of till are presented in map form (Figure 14, Chart A-1, back pocket). The majority of sites containing less than 6000 ppm Mn overlie ijolitic and granitic bedrock, while those containing greater than 6000 ppm are generally located over areas of carbonatitic bedrock. The discrimination of bedrock types using Mn is not as clear as that obtained with Zn, Ni, or Ti.

Niobium

Sixty-five percent of 'B' horizon soil samples contain less than 100 ppm Nb (Figure 16, Chart A-2, back pocket). Stations overlying carbonatitic rocks and carbonatite-ijolite contacts are clearly distinguished from those overlying ijolitic rocks in that the former have Nb concentrations in excess of 400 ppm, whereas the latter generally contain less than 100 ppm.

A similar concentration range and distribution pattern exists for the Nb contents of – 250 mesh till samples (Figure 17, Chart A-2, back pocket). Fewer samples contain abnormally high Nb values, although any that do are coincident with carbonatitic rocks.

Sixty percent of the heavy mineral separates contain less than 200 ppm Nb. Samples containing less than 400 ppm overlie ijolitic and granitic rocks, whereas those with greater than 400 ppm are located over carbonatitic bedrock (Figure 18, Chart A-2, back pocket). This distribution pattern is similar to that of Nb in 'B' horizon soils, except that several anomalous heavy mineral samples are located in the southeastern corner of the complex and to the southwest of Mornic Lake.

The distributions of Nb in 'B' horizon soils and in the heavy mineral separates of till reflect clearly the distribution of rock types in the underlying carbonatite complex.

Lanthanum

Sixty-five percent of 'B' horizon soil samples contain La at or below the analytical detection limit (30 ppm) of the method employed. Samples containing less than 60 ppm La generally overlie ijolitic rocks, while those containing greater than 60 ppm generally overlie carbonatitic rocks (Figure 19, Chart A-2, back pocket). Two sites with La concentrations in excess of 240 ppm overlie granitic bedrock in the northern corner of the sample grid, while one additional anomalous site is located at the extreme southwestern end of the grid.

Most −250 mesh till samples contain less than 120 ppm La and generally overlie ijolitic rocks. Samples containing greater than 120 ppm are coincident with carbonatitic rocks (Figure 20, Chart A-2, back pocket).

The mean La concentration in the heavy mineral separates is roughly five times that of 'B' horizon soils and −250 mesh till material. The geochemical map for this parameter is similar to that for La in soils. Two sites located in the northern corner of the sample area, which have abnormally high La values in soils, contain average concentrations in this sample medium. Conversely, a site located immediately west of East Lake, which has an average La content in the soil sample, has a higher than average concentration in the heavy mineral separate (Figure 21, Chart A-2, back pocket).

Samples overlying carbonatitic rocks are characterized by higher La contents in each of the three overburden sample types.

Strontium

Sites overlying ijolitic bedrock in the core of the complex have 'B' horizon soil Sr concentrations of less than 400 ppm (Figure 22, Chart A-2, back pocket). Soil samples with Sr contents of greater than 400 ppm are located over carbonatite-ijolitie contacts. Two sites with high Sr concentrations are also located in the northern corner of the sample area where granitic bedrock predominates.

The frequency distribution of Sr in −250 mesh tills is approximately symmetric about the 200 to 300 ppm class interval (Figure 23, Chart A-2, back pocket). Samples containing less than 300 ppm are coincident with the distribution of ijolitic rocks, whereas those containing greater than 300 ppm are coincident with carbonatitic rocks and/or carbonatite-ijolite contacts.

Strontium contents of heavy mineral separates can be divided into two groups at the 600 ppm lèvel (Figure 24, Chart A-2, back pocket). Samples containing more than 600 ppm form an arcuate pattern about the periphery of the complex, coincident with the distribution of carbonatitic bedrock. The ijolitic core of the complex is characterized by heavy mineral samples containing less than 600 ppm Sr.

The Sr contents of all overburden sample types reflect the major lithologic variations in the complex. The patterns obtained from 'B' horizon soils and heavy mineral separates indicate more clearly the underlying bedrock geology.

Yttrium

Samples of 'B' horizon soil containing less than 40 ppm Y overlie ijolitic and granitic rocks (Figure 25, Chart A-2, back pocket). Samples containing greater than 40 ppm are coincident with carbonatite-ijolite contacts.

The range of Y concentrations in −250 mesh till material is less than that in soils (Figure 26, Chart A-2, back pocket). Slightly higher contents of this element are found in samples from the southern half of the complex. Samples containing the highest Y values are generally coincident with carbonatitic bedrock.

The Y contents of heavy mineral separates can be divided into two groups at the 80 ppm level (Figure 27, Chart A-2, back pocket). Sites with concentrations greater than 80 ppm are frequently coincident with carbonatite-ijolite contacts. Several values within this range also occur at sites overlying the ijolitic core of the complex. Samples taken elsewhere contain less than 80 ppm Y.

Yttrium distributions in the three overburden sample types appear to show that elevated concentrations are associated with carbonatitic rocks. There also seems to be a correspondence between higher levels of this element in soils and heavy mineral separates and the location of carbonatite-ijolite contacts.

Phosphorus

Phosphorus concentrations of 'B' horizon soils can be divided into two groups at the 0.2 percent level (Figure 28, Chart A-2, back pocket). Samples falling in the lower class overlie granitic and ijolitic rocks. Samples from the upper class, especially those containing greater than 0.4 percent, are coincident with the distribution of carbonatitic rocks and carbonatite-ijolite contacts.

The distribution pattern of P in −250 mesh tills is similar to that of the same element in soils (Figure 29, Chart A-2, back pocket). There is a more definite correspondence, however, between elevated P levels in −250 mesh tills and carbonatite-ijolite contacts. Two samples with abnormally high concentrations are located over the ijolitic core of the complex, while two more are situated over granitic rock in the northern corner of the sample area.

A natural break occurs at 4.0 percent in the frequency distribution of P in heavy mineral separates (Figure 30, Chart A-2, back pocket). Samples containing less than 4.0 percent generally overlie granitic and ijolitic rocks, whereas those containing greater than 4.0 percent are frequently close to carbonatite-ijolite contacts.

In general, high P contents in all overburden sample types are associated with carbonatite-ijolite bedrock contacts and the highest contrast pattern is obtained from the −250 mesh till material.

Summary

Over the Prairie Lake carbonatite complex proper, the materials sampled were tills and/or residual soils (i.e. materials of local origin), whereas those sampled about the periphery of the complex were well-sorted, non-till material of more distant origin. Geochemical data from samples collected over the complex can be expected to reflect the local bedrock geology, whereas data from samples collected on the periphery of the complex may or may not reflect bedrock geology, depending upon the source of the overburden material.

At this reconnaissance scale, sites overlying carbonatitic bedrock are characterized by higher concentrations of Zn, Ni, Ti/TiO_2, Mn, Nb, La, Sr, Y, and P than those overlying ijolitic bedrock. Similar geochemical map patterns are derived from all sample types for Zn and Ni results. Optimum contrast for Ti/TiO_2, Nb, Sr, and Y is obtained from the heavy mineral separates. In the case of P, the highest geochemical contrast is obtained from the −250 mesh till fraction.

PRAIRIE LAKE DETAILED AREA

The detailed study area, outlined on all Prairie Lake geochemical maps, covers the southwestern portion of the complex where carbonatite and ijolite rock units interfinger. Two uranium showings are located in this area: the "North Highgrade showing", southeast of Anomaly Lake, lies entirely within the detailed area, while a portion of "Jim's showing", southwest of the middle of Centre Lake, is included at the northeastern end of the detailed grid. The most closely spaced sampling was conducted over the "North Highgrade showing". Since the bedrock geology of the area is depicted in sufficient detail on the geochemical maps, no bedrock geology map is included. The distributions of Zn, Ni, Ti/TiO_2, P, Nb, Sr, La, and Y are presented as geochemical maps (Charts B-1 and B-2, back pocket) and the results are described below.

Zinc

A distinct break occurs at 200 ppm in the frequency distribution of Zn concentrations in 'B' horizon soils (Figure 31, Chart B-1, back pocket). Samples containing less than 200 ppm generally overlie ijolitic rocks. Those containing greater than 200 ppm, and in particular greater than 400 ppm, are clustered about the radiometric and mineral occurrences which constitute the "North Highgrade showing". Samples containing greater than 800 ppm Zn are generally located near carbonatite-ijolite contacts.

The Zn distribution pattern for −250 mesh till samples is similar to that for soils (Figure 32, Chart B-1, back pocket). The pattern of elevated Zn values in the vicinity of the showing does not extend as far to the southwest, however, and is higher in contrast parallel to the bedrock contacts (and topographic depressions) in this sample type, relative to the soils.

The distribution of Zn in the heavy mineral separates is shown in Figure 33 (Chart B-1, back pocket). Samples having concentrations of less than 500 ppm are classified as background. Those containing greater than 500 ppm form a pattern, coincident with the "North Highgrade showing", which is more restricted than that obtained from either of the other sample types.

Zinc distributions in all sample media outline the "North Highgrade showing", with data from heavy mineral separates providing the most definitive anomaly.

Nickel

The histogram for Ni in 'B' horizon soils indicates a sharp break in the distribution at 40 ppm (Figure 34, Chart B-1, back pocket). Samples containing less than 40 ppm are classed as background. Those with concentrations greater than 40 ppm form an anomalous pattern over and to the southwest of the "North Highgrade showing", similar to the pattern of Zn values in soils. Three samples containing greater than 60 ppm Ni are located along the southeastern margin of the sample grid.

Forty-nine percent of the Ni results for – 250 mesh till samples fall below 40 ppm (Figure 35, Chart B-1, back pocket) and are classified as background. Samples containing greater than 100 ppm are considered anomalous and form a pattern coincident with the known showing. The pattern is strongest at the southeastern end of the zone, in contrast to that obtained from soil data. Of the three sites along the southeastern margin of the grid, which have anomalous Ni concentrations in soil (Figure 34, Chart B-1, back pocket), only one is anomalous in this sample medium.

The geochemical map for Ni in heavy mineral separates is shown in Figure 36 (Chart B-1, back pocket). The pattern of samples having anomalous Ni concentrations (in this case, greater than 160 ppm) is more restricted and of lower contrast than those obtained from the other sample media. A small anomalous pattern southwest of Anomaly Lake is separated from the main pattern. Only one site along the southeastern margin of the grid is anomalous, as in the case of the – 250 mesh till fraction.

Nickel maps for all three sample types outline the "North Highgrade showing", with soil results providing the most extensive and highest contrast anomalous pattern over the mineralized area.

Titanium

The frequency distribution of Ti concentrations in 'B' horizon soils displays a sharp break at the 1.0 percent level (Figure 37, Chart B-1, back pocket). Samples containing less than 1.0 percent are classed as background and generally overlie ijolitic rocks. Anomalous Ti values (greater than 1.0 percent) are generally found at sites which overlie carbonatitic rocks or carbonatite-ijolite contacts, particularly in the area of the "North Highgrade showing". Isolated anomalous values occur in the extreme northern corner and along the southeastern margin of the grid, over or in proximity to carbonatitic rocks.

The histogram for Ti concentrations in – 250 mesh till samples suggests that two overlapping populations are present, with peaks in the 0.6 to 0.7 percent and 0.9 to 1.0 percent class intervals (Figure 38, Chart B-1, back pocket). Samples belonging to the upper group (greater than 1.0 percent Ti) are frequently adjacent to, or along strike from, carbonatite-ijolite contacts. The overall pattern is much more diffuse than that of the corresponding soil data.

The distribution of TiO_2 in heavy mineral separates is shown in Figure 39 (Chart B-1, back pocket). Samples with concentrations of less than 3.0 percent typically come from sites underlain by ijolitic rocks. A broad zone of samples containing greater than 3.0 percent is coincident with the area of the showing. A large proportion of the samples containing greater than 9.0 percent TiO_2 overlie carbonatitic bedrock.

The distributions of Ti/TiO_2 in all sample types reveal anomalous concentrations in the vicinity of the "North Highgrade showing". Results from the −250 mesh and heavy mineral fractions of till suggest a correspondence, in areas remote from known mineralizaton, between 1) samples in the lowest concentration range and the presence of ijolitic bedrock, and 2) samples in the next higher concentration range and the presence of carbonatitic bedrock.

Phosphorus

A break in the distribution of P concentrations in 'B' horizon soils occurs at the 0.8 percent level (Figure 40, Chart B-1, back pocket). Samples containing less than 0.4 percent P are located over ijolitic rocks remote from mineral showings; there is a tendancy for sites over carbonatitic rocks remote from mineral showings to have values over the broader 0 to 0.8 percent range. Sites with elevated P contents (greater than 0.8 percent) form an anomalous pattern coincident with the "North Highgrade showing" area. The highest values overlie ijolitic rocks.

The geochemical map for P in −250 mesh till material is shown in Figure 41 (Chart B-1, back pocket). On the basis of the histogram, the results can be grouped into three broad classes: (1) less than 0.5 percent - background; (2) 0.5 to 1.5 percent - possibly anomalous; and (3) greater than 1.5 percent - anomalous. Samples belonging to the background class are located over both carbonatitic and ijolitic rocks remote from known showings. Those belonging to the second group form a broad pattern coincident with the "North Highgrade showing". Stations classified as anomalous occur along the southwestern edge of the possibly anomalous pattern and at three separate locations along the margin of the sample grid.

Heavy mineral separates containing less than 4 percent P are considered background and were generally collected over both carbonatitic and ijolitic rocks remote from known mineral occurrences (Figure 42, Chart B-1, back pocket). Three of the four radiometric anomalies are outlined by P values of greater than 4 percent in heavy mineral separates. An anomalous pattern unrelated to known mineralization occurs along the southeastern margin of the grid.

Elevated levels of P in all sample types outline the area of the "North Highgrade showing". Results from the heavy mineral fraction display the closest association with known mineral occurrences.

Niobium

Niobium concentrations in 'B' horizon soils occupy a considerable range. Forty-five percent of the samples contain less than 200 ppm (Figure 43, Chart B-2, back pocket) and the majority of these are located over ijolitic rocks remote from mineralization. Samples overlying carbonatitic rocks remote from known mineral occurrences have slightly higher concentrations. A pattern of samples with distinctly higher Nb contents (up to 2000 ppm) is coincident with ijolitic rocks and carbonatite-ijolite contacts near the "North Highgrade showing". Anomalous areas are also located in the north corner of the grid (along strike from "Jim's showing") and along the southeastern margin of the grid.

The distinct contrast between background and mineralized areas shown by the soil data is repeated for Nb in –250 mesh till samples (Figure 44, Chart B-2, back pocket). In this case, however, the anomalous zone is more restricted and has a distinct linearity which parallels the bedrock contacts.

Approximately 58 percent of the heavy mineral separates contain less than 400 ppm Nb, their locations coinciding with the distribution of ijolitic bedrock remote from known mineralization (Figure 45, Chart B-2, back pocket). The pattern of sample sites with greater than 800 ppm Nb in the heavy mineral separates encompasses the area of the "North Highgrade showing" and is characterized by linear trends paralleling the carbonatite-ijolite contacts. The two anomalous stations located on the southeastern margin of the grid could indicate an extension of the known mineralized zone to the southeast.

There is a marked contrast in Nb values between samples taken close to, and at some distance from, known mineral occurrences. In areas remote from known showings, there is a tendency for samples which overlie carbonatitic rocks to have slightly higher Nb values than those overlying ijolitic rocks.

Strontium

The frequency distribution of Sr results for 'B' horizon soils is positively skewed (Figure 46, Chart B-2, back pocket). A broad area outlined by samples containing greater than 400 ppm corresponds to part of the "North Highgrade showing". A second anomalous zone occurs about 200 m to the southwest. Soil samples taken at sites remote from the known mineral occurrences have Sr values of less than 400 ppm.

The histogram for Sr contents of –250 mesh till samples displays a break at the 700 ppm level (Figure 47, Chart B-2, back pocket). Values below this break are symmetrically distributed and are classified as background. Several isolated clusters of samples containing greater than 600 ppm Sr are adjacent to radiometric anomalies, although this relationship is not universal.

There is an abrupt change, at the 1600 ppm level, in the continuity of the histogram for Sr in heavy mineral separates (Figure 48, Chart B-2, back pocket). Samples containing less than 1600 ppm are considered background; they come from sites situated over both ijolitic and carbonatitic rocks remote from known mineral occurrences. Samples containing greater than 1600 ppm coincide with three of the four indicated radiometric anomalies. A number of anomalous sites occur along the southeastern margin of the grid and one anomalous station is located 300 m northeast of Anomaly Lake on the northwestern margin of the grid.

The distribution of higher Sr values in all sample types appears spatially related to the radiometric anomalies. Results from the heavy mineral separates provide the highest anomaly contrast. No reliable indication of the underlying bedrock type (carbonatite vs. ijolite) can be obtained using Sr results from sites remote from mineralization.

Lanthanum

The geochemical map for La in 'B' horizon soils is shown in Figure 49 (Chart B-2, back pocket). Approximately half of the samples contain less than 80 ppm La and three-quarters of these have concentrations at or below the analytical detection limit of the method used. These samples are classified as background and come from sites overlying both principal rock types in the complex. A contour line enclosing samples which contain greater than 160 ppm La outlines the northern radiometric anomalies, but not the two to the south. There is a poorly defined easterly trend to the anomalous La pattern, starting south of Anomaly Lake.

There is a break, at the 200 ppm level, in the histogram for La contents of −250 mesh till samples (Figure 50, Chart B-2, back pocket). Samples containing less than 160 ppm are classified as background. The clearly anomalous samples (greater than 240 ppm) form two linear patterns roughly parallel to the carbonatite-ijolite contacts and to topographic depressions. There is no correspondence between anomalous values in this sample type and known mineral occurrences.

The pattern of La distribution in heavy mineral separates (Figure 51, Chart B-2, back pocket) is similar to that in soils (Figure 49). The easterly trend noted on the soils map is more sharply defined on this map. Samples overlying ijolitic rocks generally contain less than 250 ppm La, whereas those overlying carbonatitic rocks tend to have concentrations in the 250 to 500 ppm range.

The distributions of La in soils and heavy mineral separates are similar to those for the corresponding Sr data.

Yttrium

The histogram for Y contents of 'B' horizon soils is positively skewed (Figure 52, Chart B-2, back pocket). Samples with concentrations of less than 40 ppm are considered background. Samples containing greater than 40 ppm are coincident with, or adjacent to, all indicated radiometric anomalies. Anomalous zones are also located south of Anomaly Lake along the carbonatite-ijolite contact and along the southeastern margin of the grid.

Since the frequency distribution of Y results for −250 mesh till samples is almost identical to that for soils, the same concentration intervals have been used. The geochemical map patterns are likewise similar (Figure 53, Chart B-2, back pocket).

The majority of the Y results (54 percent) for the heavy mineral separates fall within the 50 to 100 ppm interval (Figure 54, Chart B-2, back pocket). There is an easterly-trending pattern, starting southeast of Anomaly Lake, of samples containing anomalous amounts (greater than 100 ppm) of Y. A number of isolated anomalous sample sites are scattered throughout the area.

The Y geochemical maps resemble, in part, those for La and Sr.

Summary

The materials sampled within the Prairie Lake detailed area are tills where overburden is thickest, and tills and/or residual soils where bedrock lies near the surface. A large number of the stations sampled in the area of the "North Highgrade showing" show elevated concentrations of Zn, Ni, Ti/TiO_2, P, Nb, Sr, La, and Y in all sample types. Results for P, Nb, Sr, La, and Y, particularly in the heavy mineral separates, indicate best the locations of known radiometric anomalies within the showing area. Discrimination between the two major rock types exposed in the area, based upon the distributions of the latter suite of elements, is difficult because of the close interfingering relationship of the two major rock types.

KILLALA LAKE AREA

The Killala Lake complex has a surface area of approximately 109 km^2. A survey area located over the southwest corner of the complex, and underlain by three of the four major rock types comprising the complex, was selected for overburden sampling. The distributions of Zn, Cu, P, Ni, Nb, La, and Ba in selected sample materials are presented in map form (Charts C-1 and C-2, back pocket). The bedrock geology of the area is shown in Figure 63 which appears on both charts.

Zinc

A distinct break occurs in the 70 to 80 ppm class interval on the histogram of Zn concentrations in 'B' horizon soils (Figure 55, Chart C-1, back pocket). Approximately 60 percent of the samples contain less than 60 ppm Zn and are classified as background. The majority of samples containing greater than 60 ppm come from sites which overlie gabbroic bedrock.

Ninety percent of the −250 mesh till samples have Zn concentrations of less than 60 ppm (Figure 56, Chart C-1, back pocket). Samples containing greater than 60 ppm come from sites which overlie both syenitic and gabbroic rocks. The 'B' horizon soil samples from these same sites also contain greater than 60 ppm Zn; however, not all soil samples with greater than 60 ppm are associated with a −250 mesh till sample from the same site which also contains in excess of 60 ppm.

The majority of heavy mineral separates contain less than 240 ppm Zn (Figure 57, Chart C-1, back pocket). A cluster of four samples containing greater than 240 ppm Zn is located in the southwestern portion of the syenite unit. One sample in the 240 to 360 ppm range lies to the west of the detailed sample area.

Copper

Copper concentrations in 'B' horizon soils can be divided into two groups, with samples containing less than 50 ppm being considered background. The majority of the samples containing greater than 50 ppm Cu come from sites which overlie gabbroic bedrock (Figure 58, Chart C-1, back pocket).

Copper contents of −250 mesh till samples can be divided into three groups, based upon the form of the histogram (Figure 59, Chart C-1, back pocket). Samples containing less than 40 ppm Cu typically overlie syenitic bedrock; those containing 40 to 60 ppm coincide with metasediments in the southwestern portion of the grid; and any samples containing greater than 60 ppm Cu are found along the southwestern half of the gabbroic map unit.

Both frequency and map distributions of Cu in heavy mineral separates (Figure 60, Chart C-1, back pocket) are similar to those of the −250 mesh till samples, although the proportion of samples containing greater than 80 ppm Cu is higher in the −250 mesh till fraction.

The distribution of Cu in each of the overburden sample types reflects the two major bedrock units (gabbro and syenite) exposed in the survey area.

Phosphorus

Results for 'B' horizon soils and −250 mesh till samples indicate that the limited number of samples with elevated P concentrations occur in isolated localities, generally underlain by gabbroic rocks. No maps are presented for these parameters.

The distribution of P in heavy mineral separates is shown in Figure 61 (Chart C-1, back pocket). The histogram reveals that the majority of samples contain less than 1.6 percent P; these come from sites overlying syenitic bedrock. Samples containing greater than 2.4 percent P occur along the gabbro-metasediment contact in the southwestern part of the survey area.

Nickel

Approximately 70 percent of the 'B' horizon soil samples contain less than 40 ppm Ni and are considered background (Figure 63, Chart C-2, back pocket). These samples come mainly from sites overlying syenitic bedrock. Samples containing greater than 40 ppm Ni come from sites underlain either by gabbro or, in the southwestern part of the grid, mainly metasediments.

Both the histogram and geochemical map for Ni in −250 mesh till material (Figure 64, Chart C-2, back pocket) are similar to those for the soils. The pattern of samples containing greater than 40 ppm Ni over the gabbro unit, especially towards the southeastern end of its outcrop area, is of higher contrast than that obtained using the soil data.

The frequency distribution of Ni values in the heavy mineral separates of till is roughly symmetric about the 80 to 100 ppm class interval (Figure 65, Chart C-2, back pocket). Samples from sites overlying syenitic rocks typically contain less than 80 ppm, while those containing greater than 80 ppm generally come from sites overlying gabbroic rocks. There is a tendency for samples from sites overlying the nepheline syenite phase of the syenitic unit to have Ni concentrations in the 80 to 120 ppm range.

The distribution of Ni in overburden samples serves to differentiate between the contrasting syenitic and gabbroic bedrock types. In addition, results from the heavy mineral separates are a useful criterion for further subdivision of the syenitic unit into syenite and nepheline syenite phases.

Niobium

Only a limited number of soil and – 250 mesh till samples contain Nb in quantities above the analytical detection limit; these samples come from isolated sites, generally overlying syenitic bedrock. No maps are presented for the distribution of Nb in these sample types.

Based on the distribution of Nb concentrations in heavy mineral separates (Figure 66, Chart C-2, back pocket), the results can be divided into three groups: (1) samples containing less than 20 ppm generally overlie gabbroic rocks in the southeastern part of the grid; (2) those containing 20 to 80 ppm are situated over all rock types exposed in the area; and (3) those containing greater than 80 ppm most frequently overlie the syenite map unit. Also, several samples in the latter group overlie the gabbro unit in the northwestern portion of its outcrop area.

Lanthanum

The majority (64 percent) of the La results for 'B' horizon soils are at or below the analytical detection limit (Figure 67, Chart C-2, back pocket). Samples with detectable concentrations of this element come predominately from sites in a belt crosscutting all rock types along the northwest side of the survey area. Since the distributions of La in the – 250 mesh fraction and heavy mineral separates of till are similar to that of Nb in soils, no maps are presented for these two sample types.

Barium

The histogram for Ba contents of 'B' horizon soils displays a break in the 200 to 240 ppm class interval (Figure 68, Chart C-2, back pocket). Samples containing less than 200 ppm come from sites which overlie syenitic bedrock in the southeastern portion of its outcrop area. Samples from the northwestern part of the survey area have the highest concentrations of this element. The pattern crosscuts all rock types, as was the case for La in soils. Since no meaningful distribution patterns were evident for Ba results from the −250 mesh fraction and heavy mineral separates of till, no maps are presented for these parameters.

Summary

The distributions of Cu and Ni, particularly in the −250 mesh till fraction, clearly outline the distribution of the gabbroic rocks. The distribution of P in the heavy mineral separates of till indicates a pattern of anomalous samples along the southwestern contact of the gabbro, where an olivine-rich phase containing apatite predominates. This parameter thus provides a means of further subdividing the gabbro unit using overburden geochemistry. The distribution of Nb in the heavy mineral separates also aids in mapping the underlying geology by outlining areas with the high metal contents characteristic of syenitic bedrock.

The distribution of Zn does not provide patterns which can be consistently related to known bedrock geology. Patterns of abnormally high Ba and La values in 'B' horizon soils crosscut geological units on the northwestern margin of the survey area. Similar patterns are not discernible for these elements in either of the till materials. The anomalous patterns of metals which show positive correlation with underlying bedrock (Cu, Ni, Nb, and P) often diminish in clarity towards the northwestern edge of the sample area. This feature may be the result of mixing between till and sandy non-till material related to the discharge channel from Sandspit Lake to Killala Lake.

KILLALA LAKE DETAILED AREA

The location of the detailed study area is outlined on all Killala Lake reconnaissance geochemistry maps. The area overlies mainly gabbroic bedrock to the south of, and along strike from, the Killala Lake copper-nickel occurrences (Coates 1970). Since the bedrock geology of the area is simple and is depicted in sufficient detail on the geochemical maps, no bedrock geology map is included. Geochemical maps are presented for Cu, Ni, Ti/TiO_2, and P in all sample types (Chart D, back pocket) and the results are described below.

Copper

On the histogram of Cu concentrations in 'B' horizon soils, a distinct break occurs in the 50 to 60 ppm class interval (Figure 69, Chart D, back pocket). Samples containing less than 50 ppm are classified as background. A linear pattern of samples containing greater than 50 ppm, situated over the southwestern half of the area underlain by gabbro, parallels the gabbro-metasediment contact along strike from the Killala Lake showing.

The histogram of Cu results for –250 mesh till material displays two distinct populations (Figure 70, Chart D, back pocket), similar to the distribution of Cu in the soils. The trend of anomalous values is similar to, but of higher contrast than that shown by Cu in soils.

The distribution of Cu in heavy mineral separates (Figure 71, Chart D, back pocket) is similar to those in soils and –250 mesh till material.

Nickel

The frequency distribution of Ni values in 'B' horizon soils is positively skewed (Figure 72, Chart D, back pocket). Samples containing less than 40 ppm are classified as background. Sites with Ni concentrations of greater than 60 ppm form an anomalous pattern similar in extent to that revealed by the distribution of Cu in soils (Figure 69). A zone of possibly anomalous stations (40 to 60 ppm Ni) occurs in the northeastern part of the area underlain by gabbro.

The areal and statistical distributions of Ni values in –250 mesh tills (Figure 73, Chart D, back pocket) are similar to those for the same element in soil samples.

The mean Ni concentration in the heavy mineral separates is twice that of either the soils or –250 mesh tills. A broad pattern of elevated values (greater than 100 ppm) occupies the central part of the area underlain by gabbro (Figure 74, Chart D, back pocket). This lies slightly to the northeast of the anomalous Cu pattern in this same sample medium (Figure 71).

Titanium

The frequency distribution of Ti values in 'B' horizon soils (Figure 75, Chart D, back pocket) displays two peaks and suggests the possibility of two overlapping sample populations. Samples containing greater than 0.6 percent are generally located over the eastern portion of the gabbro unit (or the inner part of the unit, when it is viewed relative to the entire complex); those samples containing less than 0.6 percent Ti are situated over the western portion of the gabbro (the outer or peripheral part, relative to the complex as a whole).

A pattern similar to that in soils is formed by Ti values in –250 mesh till samples (Figure 76, Chart D, back pocket).

The distribution of TiO_2 in heavy mineral separates displays the same general pattern (Figure 77, Chart D, back pocket) with the exception of a group of three samples with low (less than 0.8 percent) concentrations. These samples come from the interior portion of the gabbro unit where TiO_2 values are characteristically higher.

Titanium/titania distributions are similar in all sample types and are interpreted as reflecting phase variations in the underlying gabbro.

Phosphorus

A distinct break occurs at the 2000 ppm level on the histogram of P concentrations in 'B' horizon soil samples (Figure 78, Chart D, back pocket). Samples containing less than 2000 ppm are considered background. Three stations whose soil samples contain greater than 2000 ppm are aligned parallel to the western (outer) gabbro contact within the outer half of the area underlain by gabbro. Three additional isolated sites contain P at this concentration level.

The frequency distribution of P values in – 250 mesh till samples is similar to that for soils and, likewise, samples containing less than 2000 ppm are considered as background (Figure 79, Chart D, back pocket).

Three peaks are present on the histogram of P concentrations in heavy mineral separates: in the 0.4 to 0.8 percent, 1.2 to 1.6 percent, and 2.8 to 3.2 percent class intervals (Figure 80, Chart D, back pocket). Samples containing less than 1.0 percent P are considered background. Three isolated sites have P concentrations of greater than 3.0 percent in this medium.

In general, a linear trend of samples with above-average P concentrations lies parallel to and 150 m east of the western gabbro contact.

Summary

The concentrations of Ni and Ti/TiO_2 in all three sample types are generally higher at sites in the interior portion of the area underlain by gabbro. These relationships are thought to reflect phase variations within the gabbro. The distribution of samples with higher concentrations of Cu, Ni, and P follows a linear trend which parallels the western gabbro contact and generally overlies the peripheral half of the gabbro. This anomalous trend is on strike with the Killala Lake Mines Limited sulphide occurrences and may warrant more detailed assessment. The concentration levels of Cu, Ni, Ti, and P are similar in 'B' horizon soils and the – 250 mesh fraction of tills. In the heavy mineral separates of tills, the concentrations of Cu and Ni are twice, and those of Ti and P considerably higher than, the corresponding levels in other sample types.

DISCUSSION

The overburden geochemistry survey reported here comprises but one phase of a comprehensive investigation of the geology and mineral potential of carbonatite and alkalic complexes in Ontario (Sage 1974). Quaternary sediments overlying well-exposed and well-mapped carbonatite and alkalic complexes were sampled and chemically analyzed in order to establish the optimum combination of sample type and trace element suite for use in geological evaluation of less well-exposed complexes in the province.

The results obtained in this survey were dealt with in the previous section. A summary of the results and additional information relating to the use of overburden geochemistry in the geological evaluation of carbonatite and alkalic complexes are presented in this section.

Geochemical Data Assessment

The initial data assessment consisted of estimating analytical precision (i.e. reproducibility of the chemical results). Assuming suffciently precise chemical data, the next consideration was that of map stability, where the stability of a geochemical map refers to its reproducibility upon repeat sampling and chemical analysis (Miesch 1976). These data assessment techniques are statistical in nature and are especially helpful where the geologist is faced with selecting the optimum combination from a wide variety of potentially useful sampling media and trace elements. However, as many of the data sets do not display the ideal frequency distribution assumed by the statistical methods employed, the rigorous objective statistical analysis should be tempered by traditional, subjective, geological interpretation. In this investigation, the statistical procedures employed have provided useful guides to the final selection of geologically meaningful geochemical parameters applicable to mineral potential evaluation. Their inclusion in similar programs is recommended.

Overburden Types

All survey sample grids were oriented parallel to the regional ice transport direction to assess any dislocation effects on the overburden geochemical pattern attributable to glaciation. Both the Prairie Lake and Killala Lake complexes form prominent local topographic features. On slopes, and where bedrock lies near the surface, the overburden type found in these elevated areas consists principally of residual material. In other areas, where distance to bedrock is greater, the exposed overburden material is till. Sakrison (Technical Survey File 2.2371, Assessment Files Research Office, Ontario Geological Survey, Toronto) has described the setting at Prairie Lake in detail. The areal distribution of till and residual material is highly variable. As a consequence of these relationships, the overburden geochemistry results obtained over the complexes proper are believed to closely reflect the nature of the underlying rock types. Overburden surrounding the elevated complexes frequently consists of glaciolacustrine and outwash sands; thus, overburden geochemistry results obtained from stations in these areas may bear little relationship to underlying bedrock geology.

Summary of Results from Individual Areas

Results from the sample type/trace element combinations selected for map presentation (Charts A to D, back pocket) were discussed in detail in the previous section and are briefly summarized, by area, here.

PRAIRIE LAKE AREA

The Prairie Lake carbonatite complex consists of complexly interfingering and concentrically distributed carbonatitic and ijolitic rocks. Carbonatite predominates on the periphery and ijolite is more abundant in the core of the intrusion. Uraniferous pyrhochlore, occurring within or near ijolite containing abundant wollastonite, and apatite concentrations in contact ijolites are the sources of uranium, niobium, and phosphorus mineralization within the complex.

At the reconnaissance level, stations overlying carbonatitic rocks are characterized by higher concentrations of Zn, Ni, Ti/TiO_2, Mn, Nb, La, Sr, Y, and P, relative to those overlying ijolitic rocks. Geochemical map patterns for Zn and Ni are similar in all sample types. Optimum Ti/TiO_2, Nb, Sr, and Y contrast is provided by the heavy mineral separates and probably reflects the concentration of these elements in the more resistate minerals. The highest geochemical contrast for P is found in the − 250 mesh fraction of till.

At the detailed level, a high proportion of sites in the vicinity of the "North Highgrade showing" are characterized by elevated concentrations of Zn, Ni, Ti/TiO_2, P, Nb, Sr, La, and Y in all sample types. Results for P, Nb, Sr, La, and Y, particularly in the heavy mineral separates of till, best identify the locations of known radiometric anomalies within the showing area. Discrimination between the two major rock types exposed in the detailed sample area, based on the latter suite of elements, is difficult because of the close, interfingering relationship of the two major rock types.

KILLALA LAKE AREA

The Killala Lake alkalic complex consists of arcuate to almost completely circular lithologic units which are, from periphery to core: alkaline gabbro, nepheline syenite, and syenite. Copper-nickel mineralization is associated with an olivine-rich phase of the peripheral gabbro. Niobium occurrences have been reported from pegmatites in the central part of the complex; however, they are considered to be only a mineralogical curiosity (Coates 1970; Sage 1975). Sampling and investigation of this complex was confined to a section along its southwestern flank.

At the reconnaissance level, overburden geochemical results provide a means of mapping the underlying bedrock geology. The distribution of the gabbro unit is clearly outlined by the distributions of Cu and Ni in the − 250 mesh fraction of till. The distribution of P in heavy mineral separates displays a pattern of anomalous samples along the western or outer contact of the gabbro where an olivine-rich phase containing apatite predominates. The distribution of high Nb concentrations in the heavy mineral separates outlines the syenitic unit.

At the detailed level, concentrations of Ni and Ti/TiO_2 are generally higher in all samples collected over the interior portion of the gabbro; this relationship probably reflects phase variations within the gabbro. Sites with higher concentrations of Cu, Ni, and P form a linear trend paralleling the western gabbro contact, generally within the peripheral half of the gabbro. This anomaly occurs along strike from the Killala Lake Mines Limited sulphide occurrences and may warrant further investigation.

Comparison with Results from Other Investigations

Exploration-oriented geological and geochemical investigations of carbonatite and alkalic complexes have been conducted in Canada and abroad; these studies provide comparative data useful in the evaluation of the present survey (Webber and Jellema 1965; Vallée and Dubuc 1970; Bloomfield *et al.* 1971; Gleeson and Cormier 1971; Stockford 1972; Sandvik and Erdosh 1977; Technical Survey File 2.2371, Assessment Files Research Office, Ontario Geological Survey, Toronto).

Gleeson and Cormier (1971) report that results for Zn in the −80 mesh fraction and Nb in the +80 mesh fraction of overburden material were of assistance in outlining the St. André carbonatite, originally detected by an airborne radiometric survey. The results of this survey further support the usefulness of Nb overburden geochemical data in identifying carbonatites.

The most extensive published study on geochemical exploration of carbonatite complexes was carried out by Bloomfield *et al.* (1971) in Uganda. Evaluation of these complexes had routinely included analyses for Nb and P. However, Bloomfield's survey included analysis for a broad range of elements in soils: Co, Ni, Cr, T, V, and Mn were used as indicators of bedrock geology, while Cu, Pb, Zn, P, REE (rare earth elements, represented by La, Ce and Y), Mo, Zr, Ba, Sr, and Be were used as indicators of possible economic mineralization. While each complex investigated varied in detail, certain general patterns were noted by Bloomfield *et al.* (1971, p.101):

> A comparison of the primary and secondary dispersion patterns shows that the elements can be divided into two groups: bedrock 'indicators' and those of possible economic significance. In the present work, the former - Co, Ni, Cr, Ti, V and Mn - are of only limited use and give rather ambiguous results. However, the latter include Cu, Pb-Zn, REE, Mo, Ba-Sr, Zr, P, Nb and Be.
>
> Of the elements of possible economic significance, the rare earths, with their pathfinders Ba-Sr, and beryllium gave the most interesting results, and it is these that will be followed up in the future exploratory work. Some of the carbonatites show considerable enrichment in lanthanum (regarded as representative of the cerium earths), which probably points to local concentrations of discrete rare-earth minerals, and at least three of them give beryllium values in residual soils of almost the same order as those over known beryl pegmatites. The contributory beryllium-bearing minerals have not yet been identified.
>
> The characteristic secondary dispersion pattern associated with carbonatite complexes can be used to delineate unexposed, soil-covered bodies.

Geochemical results obtained over the Prairie Lake carbonatite are generally consistent with the findings of Bloomfield *et al.* (1971). However, as a result of pattern reproducibility investigations (Table 15), Cu data should be used with caution.

The residual nature of the overburden at Prairie Lake is in common with other such intrusions subjected to weathering in a temperate to subarctic climate. This situation can be advantageous, resulting in concentration of economically important minerals such as apatite at the Cargill deposit (Sandvik and Erdosh 1977); or it can be disadvantageous when unrecognized, leading to overly optimistic estimates of mineral potential where surface radiometric surveys are employed.

Recommendations

Overburden geochemistry surveys provide a viable means of evaluating the mineral potential of poorly exposed or buried carbonatite and alkalic complexes. Where these intrusions are covered by glacial sediments and their presence inferred by aeromagnetics, sample collection may require overburden-drilling. The results presented in this report provide suites of elements which can aid in the initial subdivision and mapping of bedrock and in the search for mineralization within favorable rock types.

Work at Prairie Lake suggests that analysis of overburden samples for Zn, P, and Nb would provide sufficient data for initial evaluation of the carbonatite environment, when the geochemistry is integrated with standard geological and geophysical survey results (mapping, magnetics, and radiometrics). Detailed exploration work carried out at Prairie Lake by New Insco Mines Limited (Technical Survey File 2.2371, Assessment Files Research Office, Ontario Geological Survey, Toronto) strongly suggests that U be added to the analytical schedule to separate Nb anomalies due to uraniferous pyrochlore from those caused by nonuraniferous pyrochlore. Their preliminary work indicates that U/Nb ratios greater than 0.3 are related to uraniferous sources, whereas background ratios are in the range 0.03 to 0.06 (Sakrison, personal communication 1977). The above geochemical program would be adequate for assessing the potential of a carbonatite to host phosphorus, niobium and uranium mineralization.

Work at Killala Lake suggests that analysis of overburden samples for Cu, Ni, P, and Nb would yield sufficient data to aid in geological mapping of the alkalic complex and provide guides to copper-nickel sulphide and niobium mineralization.

Where rare-earth mineralization is suspected or sought, the analytical schedule should be further expanded to include Sr and La.

Sampling should be confined to the residual overburden weathered from the intrusions; therefore, the sample collection phase should be preceded by an evaluation of the overburden stratigraphy in the area to assure that this criterion is met.

Both pyrochlore mineralization at Prairie Lake and sulphide mineralization at Killala Lake are localized at the contact between rock types of differing magnetic characteristics. Thus a magnetic survey may be valuable in outlining areas where detailed overburden geochemistry surveys can be most effectively employed.

APPENDIX

Estimation of Data Reliability

Introduction

An assessment of data reliability is a prerequisite to effective decision-making based on the results of this project. Reliability may be evaluated by considering the variability of individual parameters. In geochemical prospecting, the total variability of data for any element in any sample material may be considered to consist of three components: analytical (laboratory) variance, sampling (in-site) variance, and regional (between-site) variance. The latter component, regional variance, is of prime importance in mapping geological features using geochemistry.

Prior to geological interpretation of geochemical data, it is prudent to investigate the relative magnitudes of the three principal sources of data variability, (1) to identify those parameters providing the most reliable information for geochemical mapping, (2) to avoid needless expenditure of additional time and money on the interpretation and follow-up of initially unreliable results, and (3) to isolate sources of variability in order to direct future investigations. This appendix presents the methodology, results, and discussion of results for an investigation into the reliability of data obtained in this project.

Methodology

It is assumed that the total data variation for each metal in each sample type consists of analytical, sampling and regional components. Laboratory work is subject to both human and instrumental error (or variability). Human error, in this context, consists both of mistakes in laboratory techniques and of analytical compromise, i.e. the acceptance of lower analytical reproducibility in exchange for greater production and lower unit costs (Miesch 1964). Data variability attributable to laboratory sources can be estimated by using results from duplicate analyses on selected samples. Sampling errors may be related both to human error in sample collection and to natural inhomogeneities in the geological medium under investigation. Data variability related to in-site sampling can be estimated by comparing results from replicate samples taken at a number of sites. Regional variance is that which remains after accounting for the analytical and sampling components. Partitioning of the total data variability into its three principal components can be accomplished using a three-stage nested analysis of variance model (Scheffé 1959).

It is not generally practical to sample each site in duplicate. Two areas were sampled in this program (Figure 4), approximately twenty sites in each area were sampled in duplicate to assess sampling variability, and each of these samples was analyzed in duplicate to estimate laboratory variability.

These duplicate results provide the basic data input for the statistical analyses outlined below.

The three-stage nested analysis of variance model can be expressed mathematically as follows:

$x = u + V_r + V_s + V_a + e$, where
x = estimated metal concentration reported by the laboratory
u = mean metal concentration for all samples
V_r = regional (between site) variance
V_s = sampling (in-site) variance
V_a = analytical (laboratory) variance
e = random error term with mean = 0 and variance = σ^2

The regional (between-site) variance, that component upon which the discrimination of areal geological features depends, is obtained by subtraction of the analytical and sampling components from the total data variability. All three components are expressed as percentages of the total variability. The statistical significance of the data partitioning is evaluated using the F ratio test (Davis 1973, p.99-105) at the 95 percent confidence level.

Results

The results of the variance computations on both the original and $\log_{10}$ transformed data are presented for Prairie Lake in Tables 17 to 22 and for Killala Lake in Tables 23 to 28. To facilitate interpretation, the three designated principal components of the total variability for each element have been expressed as percentages of the total variance. The statistical significance of the data variance partitioning is evaluated at the 95 percent confidence level using the F ratio test. Where the computed F ratio value exceeds the critical value, a statistically significant partioning of data exists between the two variance components under consideration. Conversely where the computed F ratio value is less than the critical value, there is no statistically significant difference between the two sources of variance being examined. For example, if the F ratio comparing regional and sampling variances for a particular element is less than the critical value, it would not be possible to distinguish between the errors associated with these two sources of variability; therefore, the use of this element in geochemical mapping would not be warranted. The following is an evaluation of the results:

PRAIRIE LAKE

(1) 'B' Horizon Soils:

(i) Original Data (Table 17) - A statistically significant partitioning exists between the sampling and analytical components of variance for all elements except Sr and Nb. Variances for Mn, Zn, Ni, Co, Pb, P, Sr, La, Y, Zr, and Ti are significantly partitioned into regional and sampling components; only these elements would be potentially useful for geochemical mapping. All of these elements except Zr have greater than 50 percent of their total variability residing

TABLE 17 | RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL 'B' HORIZON SOIL GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	53.30	46.65	0.05	3.28[1]	1925.98[1]
Cu	36.48	63.07	0.45	2.15	281.94[1]
Zn	86.69	13.29	0.02	14.03[1]	1139.21[1]
Ni	63.54	36.38	0.09	4.49[1]	827.37[1]
Co	64.16	35.54	0.30	4.60[1]	237.55[1]
Pb	82.18	15.31	2.51	10.92[1]	13.21[1]
Cr	29.68	70.26	0.06	1.84	2425.33[1]
Ba	19.80	70.69	9.51	1.52	15.87[1]
P	16.35	38.57	0.07	4.18[1]	1072.21[1]
Sr	75.51	3.94	20.55	11.62[1]	1.38
La	58.02	27.07	14.91	4.36[1]	4.63[1]
Y	69.52	20.91	9.57	6.41[1]	5.37[1]
Zr	38.31	24.15	37.54	2.79[1]	2.29[1]
Mo	6.59	91.64	1.77	1.14	104.43[1]
Nb	10.77	16.66	72.57	1.41	1.46
Ti	72.72	14.94	12.34	7.89[1]	3.42[1]

Number of sites sampled in duplicate (N) = 16.

[1] A significant difference exists at the 95 percent confidence level.

in the regional component and are recommended for geochemical mapping in this area.

(ii) Log_{10} Transformed Data (Table 18) - A statistically significant partitioning exists between sampling and analytical components of variance for all elements. Variances for Mn, Zn, Ni, Co, Pb, Cr, P, Sr, La, Y, Zr, Nb, and Ti are significantly partitioned into regional and sampling components. All of this latter group except Zr have greater than 50 percent of their total variability residing in the regional component and are recommended for geochemical mapping in this area.

(2) – 250 Mesh Till Fraction:

(i) Original Data (Table 19) - A statistically significant partitioning exists between sampling and analytical components of variance for all elements. Variances for Cu, Ni, Co, Pb, Cr, Ba, Zr, and Mo are not significantly partitioned into regional and sampling components; therefore, these elements cannot be recommended for geochemical mapping. Of the remaining elements Zn, P, La, Y, Nb, and Ti have greater than 50 percent of their total variability residing in the regional component; thus only these six can be recommended for geochemical mapping.

TABLE 18 RESULTS OF VARIANCE COMPUTATUIONS ON LOG_{10} TRANSFORMED 'B' HORIZON SOIL GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	66.58	33.40	0.02	4.99[1]	4430.66[1]
Cu	38.10	61.39	0.51	2.24	239.43[1]
Zn	83.50	16.49	0.01	11.13[1]	2261.41[1]
Ni	79.61	20.18	0.21	8.85[1]	191.87[1]
Co	77.46	22.26	0.27	7.92[1]	163.91[1]
Pb	75.13	21.57	3.30	7.47[1]	14.06[1]
Cr	59.58	40.33	0.09	3.95[1]	942.10[1]
Ba	25.33	65.26	9.41	1.72	14.87[1]
P	78.46	21.37	0.17	8.32[1]	247.27[1]
Sr	74.82	9.44	15.74	9.65[1]	2.20[1]
La	66.90	24.89	8.20	5.62[1]	7.07[1]
Y	70.93	14.03	15.03	7.58[1]	2.86[1]
Zr	48.88	26.67	24.45	3.51[1]	3.18[1]
Mo	24.93	66.19	8.87	1.71	15.92[1]
Nb	78.69	16.59	4.72	9.30[1]	8.02[1]
Ti	63.75	20.25	16.00	5.51[1]	3.53[1]

Number of sites sampled in duplicate (N) = 16.

[1] A significant difference exists at the 95 percent confidence level.

TABLE 19 RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL –250 MESH TILL FRACTION GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	47.99	51.98	0.03	2.85[1]	4064.32[1]
Cu	21.56	78.34	0.10	1.55	1636.63[1]
Zn	70.48	29.42	0.11	5.78[1]	558.62[1]
Ni	16.35	83.57	0.03	1.39	2117.87[1]
Co	27.45	71.97	0.57	1.76	252.38[1]
Pb	25.48	73.22	1.30	1.69	113.54[1]
Cr	32.84	66.85	0.30	1.98	440.53[1]
Ba	0.52	97.91	1.56	1.01	126.38[1]
P	66.23	33.72	0.05	4.92[1]	1382.56[1]
Sr	49.23	44.59	6.18	3.06[1]	15.43[1]
La	53.63	39.96	6.41	3.49[1]	13.47[1]
Y	72.02	16.84	11.13	7.43[1]	4.03[1]
Zr	6.27	75.74	17.99	1.17	9.42[1]
Mo	5.53	83.29	11.17	1.12	15.91[1]
Nb	61.84	32.66	5.50	4.49[1]	12.87[1]
Ti	71.61	16.95	11.45	7.32[1]	3.96[1]

Number of sites sampled in duplicate (N) = 17.

[1] A siginificant difference exists at the 95 percent confidence level.

TABLE 20 | RESULTS OF VARIANCE COMPUTATION ON LOG$_{10}$ TRANSFORMED −250 MESH TILL FRACTION GEOCHEMICAL DATA, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	65.96	33.99	0.05	4.88[1]	1429.90[1]
Cu	41.50	58.29	0.20	2.42	576.72[1]
Zn	79.72	20.25	0.03	8.87[1]	1560.74[1]
Ni	40.88	58.96	0.16	2.38[1]	734.38[1]
Co	39.69	59.19	1.11	2.33[1]	107.33[1]
Pb	28.25	68.75	3.00	1.80	46.85
Cr	52.30	47.49	0.21	3.20[1]	447.97[1]
Ba	14.99	81.64	3.37	1.36	49.39[1]
P	61.22	38.67	0.11	4.16[1]	705.88[1]
Sr	74.74	20.23	5.03	7.57[1]	9.04[1]
La	69.90	29.08	1.02	5.72[1]	57.84[1]
Y	67.44	21.29	11.27	6.01[1]	4.78[1]
Zr	7.83	75.59	16.58	1.19	10.12[1]
Mo	32.21	59.80	7.99	2.01	15.98[1]
Nb	79.56	15.88	4.56	9.76[1]	7.96[1]
Ti	77.86	11.45	10.69	10.27[1]	3.14[1]

Number of sites sampled in duplicate (N) = 17.

[1] A significant difference exists at the 95 percent confidence level.

(ii) Log$_{10}$ Transformed Data (Table 20) - Only the variance for Pb is not significantly partitioned into sampling and analytical components. Variances for Mn, Zn, Ni, Co, Cr, P, Sr, La, Y, Nb, and Ti data are significantly partitioned into regional and sampling components. All of this latter group except Ni and Co have greater than 50 percent of their total variability residing in the regional component and can be recommended for geochemical mapping in this area.

(3) Heavy Mineral Separates of the −60 +250 Mesh Till Fraction:

(i) Original Data (Table 21) - A statistically significant difference exists between sampling and analytical components of variance for all elements. Variances for Mn, Zn, Ni, Pb, Cr, Ba, P, Sr, La, Y, Zr, Nb, and TiO_2 are significantly partitioned into regional and sampling components. Of this latter group, only Mn, Zn, Cr, P, Sr, La, Y, Nb, and TiO_2 have greater than 50 percent of their total variance residing in the regional component and can be recommended for geochemical mapping.

(ii) Log$_{10}$ Transformed Data (Table 22) - A statistically significant difference exists between sampling and analytical components of variance for all elements. Variances for Mn, Zn, Ni, Pb, Cr, Ba, P, Sr, La, Y, Zr, and Nb are significantly partitioned into regional and sampling components. All of these elements except, perhaps, Pb have greater than 50 percent of their total variability residing in the regional component and can be recommended for geochemical mapping in this area.

TABLE 21 RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL GEOCHEMICAL DATA FOR HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	83.28	16.69	0.03	10.97[1]	1002.83[1]
Cu	35.87	63.97	0.15	2.12	838.56[1]
Zn	76.05	23.80	0.14	7.37[1]	332.11[1]
Ni	47.61	52.21	0.18	2.82[1]	570.71[1]
Co	30.84	68.76	0.40	1.89	342.80[1]
Pb	43.26	56.49	0.26	2.53[1]	438.05[1]
Cr	57.60	42.01	0.39	3.73[1]	214.06[1]
Ba	41.54	57.79	0.68	2.43[1]	171.71[1]
P	86.11	13.80	0.09	13.44[1]	320.72[1]
Sr	72.60	24.88	2.52	6.55[1]	20.75[1]
La	95.92	1.80	2.28	66.35[1]	2.58[1]
Y	80.86	17.91	1.23	9.73[1]	30.02[1]
Zr	37.81	43.67	18.52	2.43[1]	5.71[1]
Mo	5.66	80.98	13.36	1.13	13.12[1]
Nb	71.59	17.11	11.30	7.29[1]	4.03[1]
TiO_2	70.01	29.83	0.16	5.68[1]	383.24[1]

Number of sites sampled in duplicate (N) = 16.

[1] A significant difference exists at the 95 percent confidence level.

TABLE 22 RESULTS OF VARIANCE COMPUTATIONS ON LOG_{10} TRANSFORMED GEOCHEMICAL DATA FOR HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, PRAIRIE LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	82.82	17.12	0.06	10.66[1]	558.32[1]
Cu	33.22	66.50	0.28	2.00	480.88[1]
Zn	82.53	17.33	0.14	10.49[1]	250.78[1]
Ni	59.45	40.40	0.15	3.94[1]	534.38[1]
Co	36.46	62.75	0.79	2.15	159.75[1]
Pb	49.98	49.73	0.29	3.00[1]	340.82[1]
Cr	75.54	24.36	0.11	7.19[1]	455.80[1]
Ba	65.21	33.78	1.01	4.80[1]	68.12[1]
P	86.51	13.42	0.07	13.86[1]	384.29[1]
Sr	87.45	11.48	1.07	15.56[1]	22.39[1]
La	89.13	10.12	0.74	17.99[1]	28.23[1]
Y	70.19	27.86	1.96	5.87[1]	29.48[1]
Zr	73.79	21.14	5.06	7.23[1]	9.35[1]
Mo	23.64	50.84	25.52	1.74	4.98[1]
Nb	84.97	12.81	2.22	13.21[1]	12.51[1]
TiO_2	22.55	77.40	0.05	1.50	2954.76[1]

Number of sites sampled in duplicate (N) = 16.

[1] A significant difference exists at the 95 percent confidence level.

TABLE 23 RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL 'B' HORIZON SOIL GEOCHEMICAL DATA, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	83.69	14.84	1.47	11.75[1]	21.14[1]
Cu	83.53	15.99	0.48	11.29[1]	67.30[1]
Zn	80.74	19.10	0.16	9.42[1]	239.29[1]
Ni	92.67	7.20	0.13	26.49[1]	111.01[1]
Co	84.13	14.27	1.60	12.16[1]	18.85[1]
Pb	34.60	56.04	9.36	2.14[1]	12.98[1]
Cr	80.21	19.54	0.25	9.16[1]	158.93[1]
Ba	62.25	21.42	16.33	5.21[1]	13.62[1]
P	61.46	38.06	0.48	4.21[1]	159.21[1]
Sr	27.48	38.68	33.84	1.99	3.29[1]
La	88.71	2.33	8.96	83.43[1]	2.08[1]
Y	67.98	2.13	29.88	8.96[1]	1.14
Zr	29.08	23.79	47.13	2.23[1]	2.01[1]
Mo	62.91	11.08	26.01	66.30[1]	6.75[1]
Nb	32.69	3.77	63.54	3.33[1]	1.13
Ti	59.91	15.36	24.73	5.32[1]	2.24[1]

Number of sites sampled in duplicate (N) = 21.

[1] A significant difference exists at the 95 percent confidence level.

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(1) 'B' Horizon Soils:

(i) Original Data (Table 23) - A statistically significant difference exists between sampling and analytical components of variance for all elements except Y and Nb. Variances for Mn, Cu, Zn, Ni, Co, Pb, Cr, Ba, P, La, Y, Zr, Mo, Nb, and Ti are significantly partitioned into regional and sampling components. All elements in this latter group except Pb, Zr, and Nb have greater than 50 percent of their total variability residing in the regional component and can be recommended for geochemical mapping.

(ii) Log_{10} Transformed Data (Table 24) - A statistically significant difference exists between sampling and analytical components of variance for all elements except Y, Zr, and Nb. Variances for Mn, Cu, Zn, Ni, Co, Cr, Ba, P, La, Y, Zr, Mo, Nb, and Ti are significantly partitioned into regional and sampling components. All of these elements except Zr and Nb have greater than 50 percent of their total variability residing in the regional component and can be used in geochemical mapping.

TABLE 24 | RESULTS OF VARIANCE COMPUTATIONS ON LOG$_{10}$ TRANSFORMED 'B' HORIZON SOIL GEOCHEMICAL DATA, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	77.19	20.58	2.23	8.12[1]	19.45[1]
Cu	74.41	24.52	1.07	6.94[1]	46.75[1]
Zn	72.74	26.91	0.36	6.37[1]	150.95[1]
Ni	91.22	7.89	0.89	22.89[1]	18.79[1]
Co	82.18	15.86	1.96	10.76[1]	17.20[1]
Pb	29.49	60.61	9.90	1.90	13.24[1]
Cr	60.19	39.13	0.68	4.05[1]	115.70[1]
Ba	66.14	15.75	18.11	6.33[1]	2.74[1]
P	61.75	37.62	0.64	4.26[1]	119.42[1]
Sr	25.45	34.06	40.49	1.94	2.68[1]
La	86.19	4.09	9.73	223.62[1]	6.28[1]
Y	64.04	4.80	31.16	7.28[1]	1.31
Zr	36.17	11.89	51.94	2.91[1]	1.46
Mo	64.64	11.32	24.04	187.34[1]	17.32[1]
Nb	35.83	8.90	55.27	4.83[1]	1.48
Ti	51.50	27.66	20.84	3.70[1]	3.65[1]

Number of sites sampled in duplicate (N) = 21.

[1] A signigicant difference exists at the 95 percent confidence level.

(2) – 250 Mesh Till Fraction:

(i) Original Data (Table 25) - A statistically significant difference exists between sampling and analytical components of variance for all elements except Sr, Zr, and Nb. Variances for all elements except La are significantly partitioned into regional and sampling components; however, Ni, Pb, Y, Zr, and Mo have less than 50 percent of their total variance residing in the regional component. Thus, the elements that can be used in geochemical mapping are Mn, Cu, Zn, Co, Cr, Ba, P, Sr, Nb, and Ti.

(ii) Log$_{10}$ Transformed Data (Table 26) - A statistically significant difference exists between sampling and analytical components of variance for all elements except Sr, Zr, and Nb. Variances for all elements except La are significantly partitioned into regional and sampling components; however, Pb, Y, Zr, and Mo have less than 50 percent of their total variance residing in the regional component. Thus the elements that can be used in geochemical mapping are Mn, Cu, Zn, Ni, Co, Cr, Ba, P, Sr, Nb, and Ti.

(3) Heavy Mineral Separates of the – 60 + 250 Mesh Till Fraction:

(i) Original Data (Table 27) - A statistically significant difference exists between sampling and analytical components of variance for all elements. Variances for Mn, Cu, Zn, Ni, Co, Cr, P, La, Y, Mo, Nb, and TiO_2 are significantly partitioned into regional and sampling components; of these, only La has less

TABLE 25 RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL –250 MESH TILL FRACTION GEOCHEMICAL DATA, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	58.95	39.29	1.76	3.94[1]	45.60[1]
Cu	75.63	24.28	0.10	7.22[1]	505.82[1]
Zn	66.24	33.09	0.67	4.96[1]	100.21[1]
Ni	49.01	50.68	0.30	3.93[1]	335.15[1]
Co	60.52	38.89	0.59	4.09[1]	133.42[1]
Pb	35.67	39.89	34.44	2.51[1]	2.74[1]
Cr	58.17	48.89	0.94	3.81[1]	87.89[1]
Ba	69.92	24.83	5.25	6.09[1]	10.46[1]
P	78.99	19.30	1.72	8.84[1]	31.34[1]
Sr	53.15	3.12	43.71	5.26[1]	1.14
La	3.88	78.09	18.04	1.10	9.66[1]
Y	43.54	36.79	19.68	2.87[1]	4.74[1]
Zr	37.08	2.85	60.07	3.25[1]	1.09
Mo	47.47	36.11	16.41	3.14[1]	5.40[1]
Nb	62.15	1.28	36.56	8.31[1]	1.08
Ti	65.69	25.26	9.05	5.41[1]	6.58[1]

Number of sites sampled in duplicate (N) = 20.

[1] A significant difference exists at the 95 percent confidence level.

TABLE 26 RESULTS OF VARIANCE COMPUTATIONS ON LOG_{10} TRANSFORMED –250 MESH TILL FRACTION GEOCHEMICAL DATA, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	56.19	41.56	2.25	3.63[1]	38.02[1]
Cu	69.87	29.83	0.30	5.66[1]	201.55[1]
Zn	60.84	38.42	0.74	4.14[1]	108.18[1]
Ni	65.16	34.15	0.69	4.78[1]	100.68[1]
Co	69.04	29.37	1.58	5.58[1]	38.12[1]
Pb	29.39	33.71	36.89	2.13[1]	2.83[1]
Cr	68.55	30.28	1.17	5.44[1]	52.81[1]
Ba	61.22	28.47	10.30	4.64[1]	6.53[1]
P	65.56	32.60	2.15	4.87[1]	31.34[1]
Sr	50.96	5.80	43.24	4.72[1]	1.27[1]
La	3.99	77.31	18.70	1.10	9.27[1]
Y	37.65	40.63	21.72	2.46[1]	4.74[1]
Zr	40.54	9.41	50.05	3.35[1]	1.38
Mo	49.23	25.44	25.32	3.58[1]	3.01[1]
Nb	60.94	0.60	38.47	7.54[1]	1.03
Ti	63.41	26.49	10.10	5.02[1]	6.25[1]

Number of sites sampled in duplicate (N) = 20.

[1] A significant difference exists at the 95 percent confidence level.

TABLE 27 RESULTS OF VARIANCE COMPUTATIONS ON ORIGINAL GEOCHEMICAL DATA FOR HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	90.54	8.57	0.89	21.10[1]	20.27[1]
Cu	87.97	11.17	0.87	16.17[1]	26.75[1]
Zn	66.52	33.31	0.18	4.98[1]	375.41[1]
Ni	78.86	20.82	0.32	8.52[1]	129.49[1]
Co	75.00	24.63	0.37	7.04[1]	135.33[1]
Pb	40.48	59.39	0.13	2.36	925.70[1]
Cr	88.66	10.87	0.47	16.97[1]	46.85[1]
Ba	5.14	75.89	18.97	1.12	9.00[1]
P	92.31	7.19	0.50	25.82[1]	29.78[1]
Sr	35.30	40.08	24.62	2.35	4.26[1]
La	46.74	42.53	10.73	2.95[1]	8.92[1]
Y	69.30	20.70	10.00	6.38[1]	5.14[1]
Zr	27.10	63.71	9.19	1.79	14.87[1]
Mo	55.84	29.65	14.50	4.03[1]	5.09[1]
Nb	53.70	22.34	23.96	4.13[1]	2.86[1]
TiO_2	87.83	11.96	0.20	15.56[1]	117.80[1]

Number of sites sampled in duplicate (N) = 13.

[1] A siginificant difference exists at the 95 percent confidence level.

TABLE 28 RESULTS OF VARIANCE COMPUTATIONS ON LOG$_{10}$ TRANSFORMED GEOCHEMICAL DATA FOR HEAVY MINERAL SEPARATES OF THE –60 +250 MESH TILL FRACTION, KILLALA LAKE AREA.

ELEMENT	APPORTIONMENT OF DATA VARIABILITY (IN PERCENT)			SIGNIFICANCE (F RATIO)	
	Regional Component (A)	Sampling Component (B)	Analytical Component (C)	$F_{A/B}$	$F_{B/C}$
Mn	91.98	7.09	0.93	25.35[1]	16.18[1]
Cu	85.72	13.10	1.18	13.52[1]	23.22[1]
Zn	79.04	20.67	0.29	8.59[1]	141.70[1]
Ni	85.87	13.35	0.79	13.50[1]	34.89[1]
Co	86.51	12.68	0.81	14.22[1]	32.20[1]
Pb	49.74	49.73	0.52	2.99[1]	190.94[1]
Cr	85.14	14.72	0.14	12.51[1]	218.73[1]
Ba	1.68	82.26	16.05	1.04	11.25[1]
P	92.61	6.88	0.51	26.97[1]	28.09[1]
Sr	61.08	16.05	22.87	5.44[1]	2.40[1]
La	47.50	40.71	11.79	3.04[1]	7.90[1]
Y	68.49	21.38	10.13	6.18[1]	5.22[1]
Zr	28.43	52.13	19.43	1.92	6.37[1]
Mo	58.28	27.16	14.57	4.38[1]	4.73[1]
Nb	68.29	14.50	17.21	6.91[1]	2.69[1]
TiO_2	92.55	7.09	0.36	26.45[1]	40.61[1]

Number of sites sampled in duplicate (N) = 13.

[1] A significant difference exitsts at the 95 percent confidence level.

than 50 percent of its total variability residing in the regional component. The remainder can be used in geochemical mapping.

(ii) Log_{10} Transformed Data (Table 28) - A statistically significant difference exists between sampling and analytical components of variance for all elements. Variances for all elements except Ba and Zr are significantly partitioned into regional and sampling components. However, Pb and La have less than 50 percent of their total variability resident in the regional component. Thus, the elements that can be used in geochemical mapping are Mn, Cu, Zn, Ni, Co, Cr, P, Sr, Y, Mo, Nb, and TiO_2.

Summary and Discussion

Common statistical techniques assume normally distributed data populations. Due to the positive skewness of many of the trace element frequency distributions, $\log_{10}$ transformed data more closely approximate the ideal of a normal distribution. Hence statistical computations based upon $\log_{10}$ transformed data may be more appropriate for certain elements. Variance computations have been carried out on both forms of the data and the results given in Tables 17 to 28.

It is generally considered that a minimum of 30 samples is required in order to interpret the result of common statistical methods in probability terms. As each duplicate data set used in this study consists of less than 30 samples, the results should be viewed as indicating tendencies of the data rather than giving clear separations which can be stated within specific confidence limits. The results, therefore, are intended as guidelines rather than final statements on the acceptability of data sets.

Failure to separate sampling and analytical sources of variance, based on the F ratio test, indicates that it is not possible to discriminate between variation in trace element content due to analytical work and that due to natural inhomogeneities in the sample material. This feature is not of great importance so long as the majority of the total variability is contained in the regional component.

Failure to separate regional and sampling sources of variability, based on the F ratio test, indicates that it is not possible to discriminate between variation in trace element content due to natural inhomogeneities in the sample material at an individual sample station and that due to differences in geochemical characteristics between sample stations. If such is the case, the stability of the geochemical map pattern is questionable and use of that element cannot be recommended for geological mapping. Furthermore, even though a significant partitioning has been achieved between regional and sampling components of variability, it may not be wise to use certain metals for geochemical mapping. Only those metals with the majority of their total variability resident in the regional component will be useful for mapping regional variations in geological material. In this report, an arbitrary cut-off of fifty percent has been adopted. Those elements whose total variability is significantly partitioned into regional and sampling components, and whose regional component constitutes 50 percent or more of the total variability, can be recommended for use in geochemical mapping. Parameters not meeting these specifications are not recommended for geochemical mapping purposes. The arbitrary nature of this cut-off should be emphasized.

Those trace element/sample type combinations which are considered suitable for geochemical mapping on the basis of the variance analysis and the above interpretative criteria have been noted in the previous section. While these results can be affected by a large number of factors (e.g. representivity of the samples, relationship between trace element concentration ranges and analytical detection limit), they do provide some standardized guidelines for choosing the parameters which would be most useful in mapping geological variations with the aid of geochemistry. The results presented here are used in the selection of trace element/sample type combinations for map representation (described in the section on Interpretational and Data Presentation Considerations) and are further discussed in the concluding section of the report.

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Chart B-1–Figures 31 to 42 (inclusive).

Chart B-2–Figures 43 to 54 (inclusive).

Chart C-1–Figures 55 to 62 (inclusive).

Chart C-2–Figures 62 to 68 (inclusive).

Chart D–Figures 69 to 80 (inclusive).

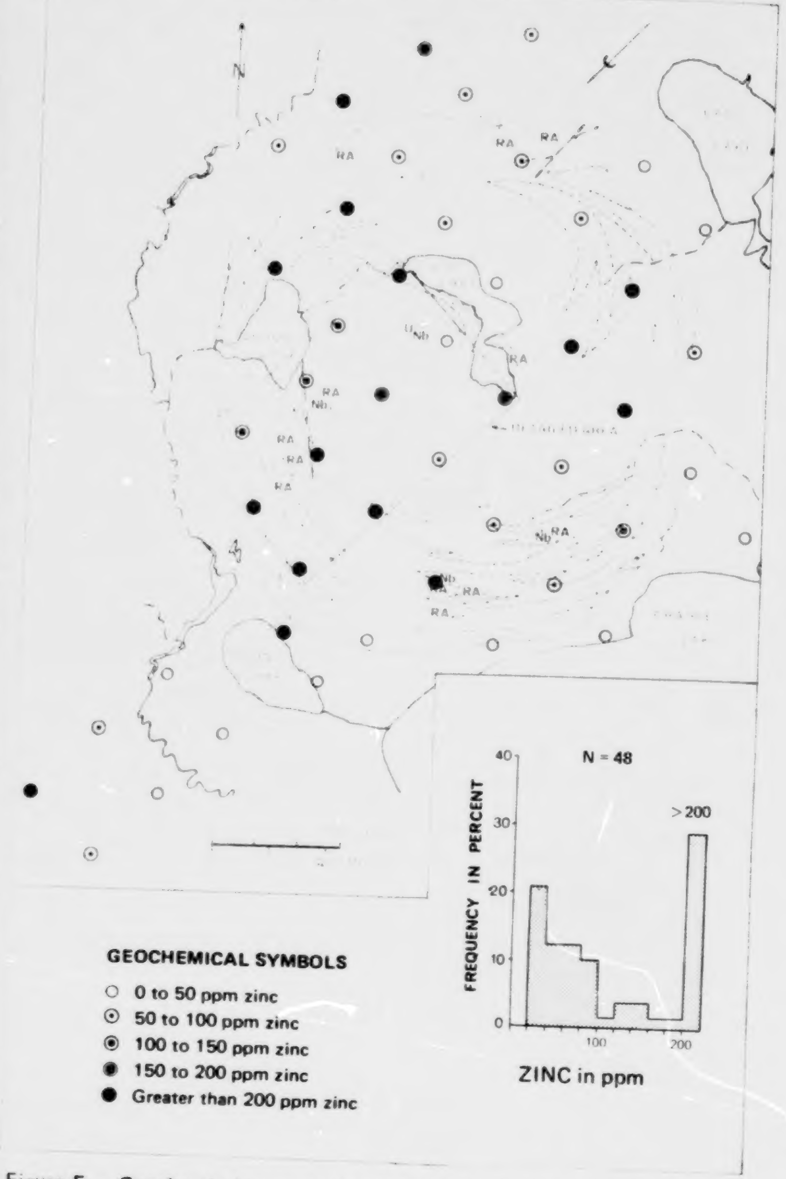


Figure 5 – Geochemical map of zinc in 'B' horizon soils, Prairie Lake area.

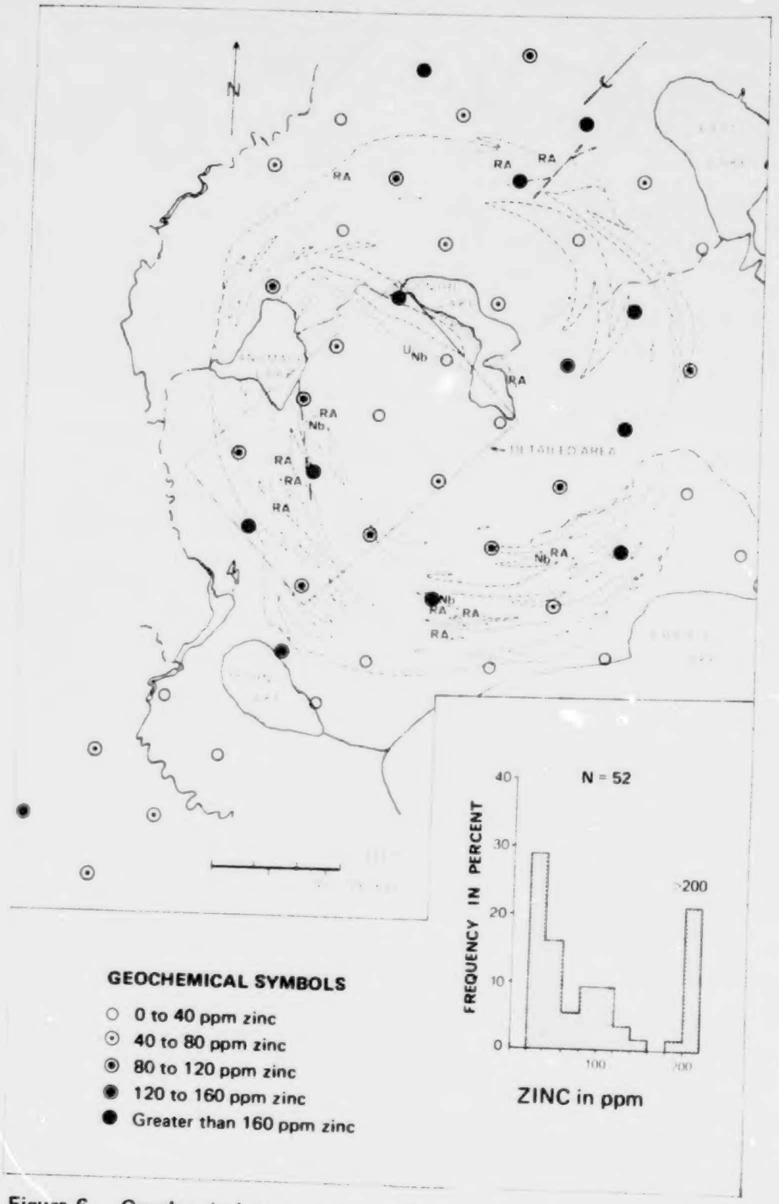


Figure 6 – Geochemical map of zinc in -250 mesh till samples, Prairie Lake area.

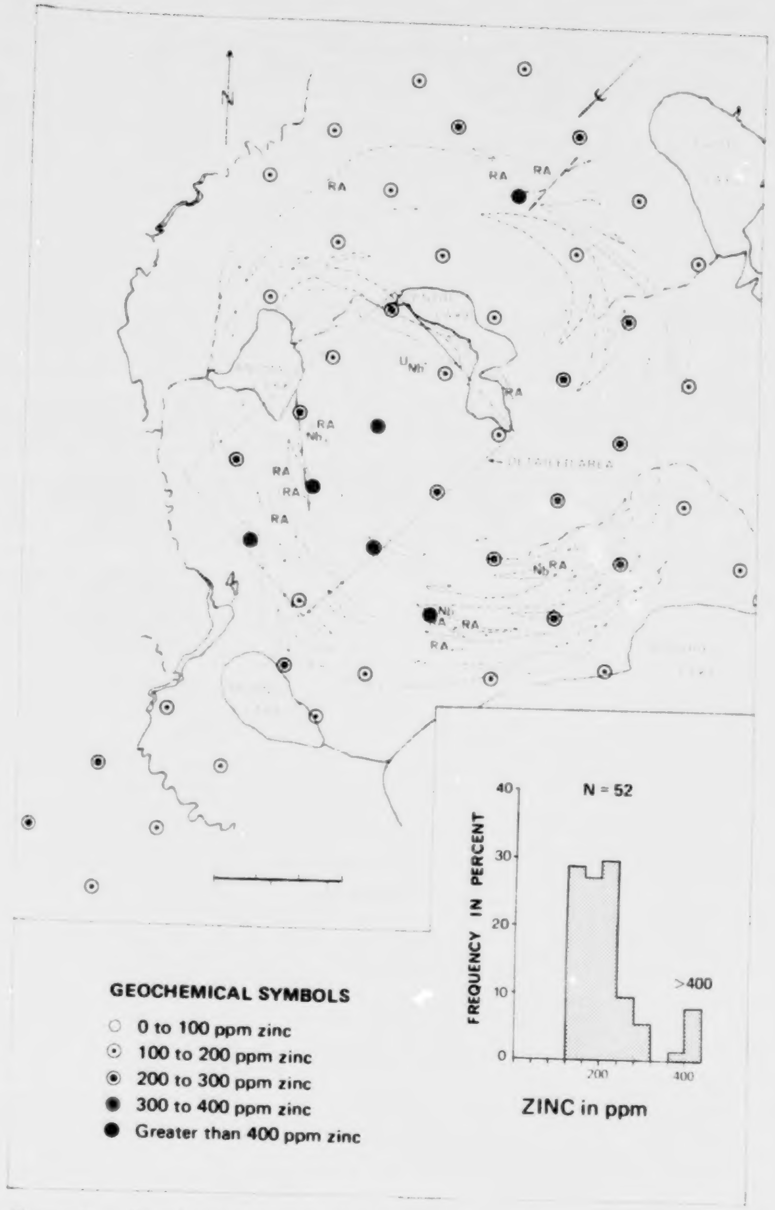


Figure 7 – Geochemical map of zinc in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

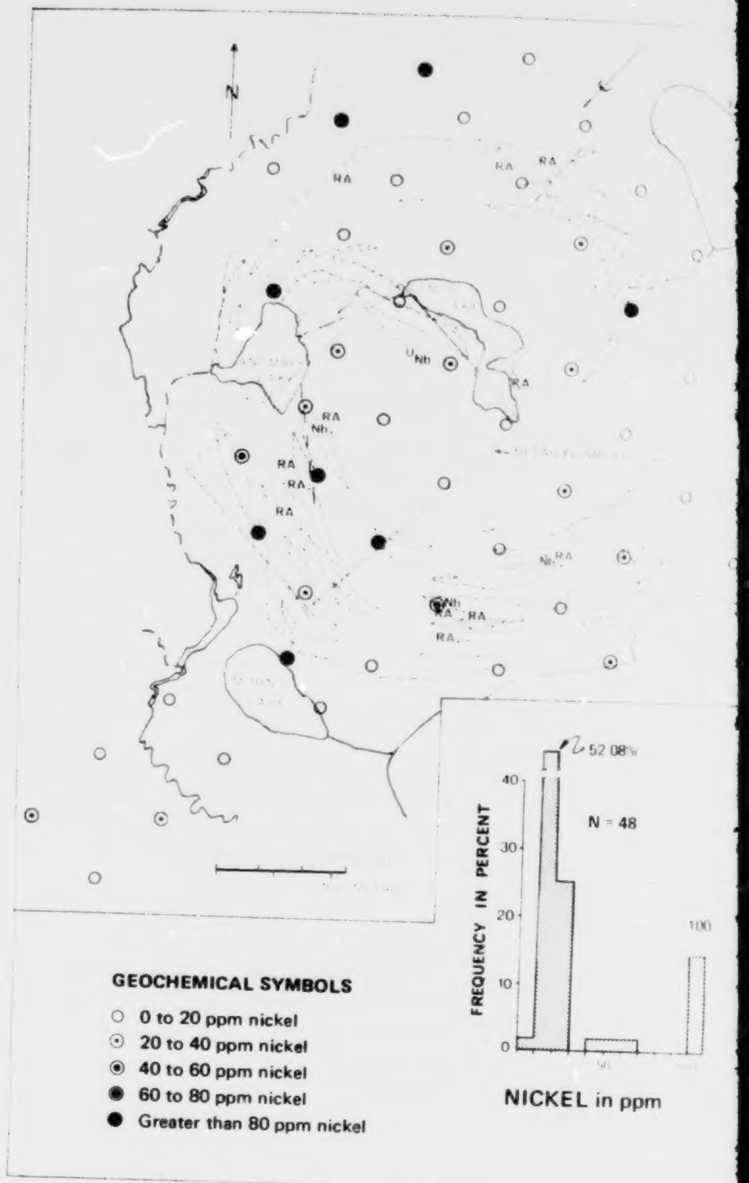
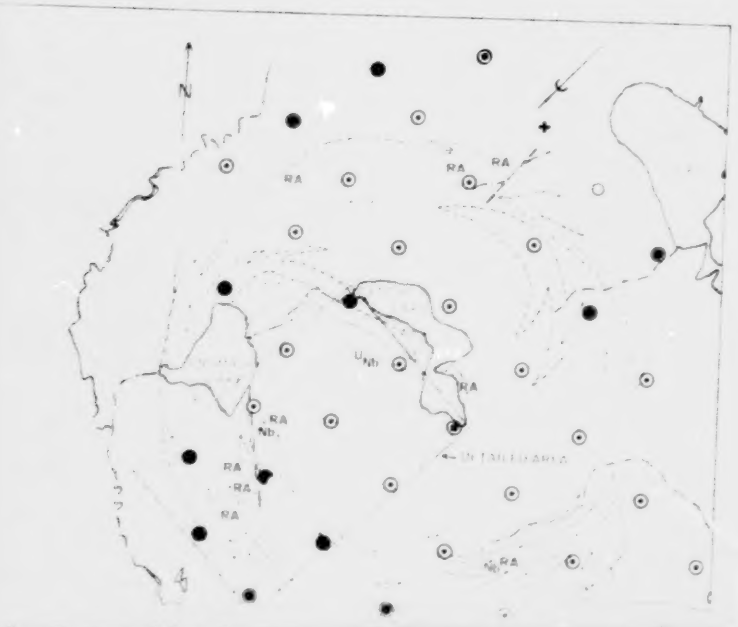
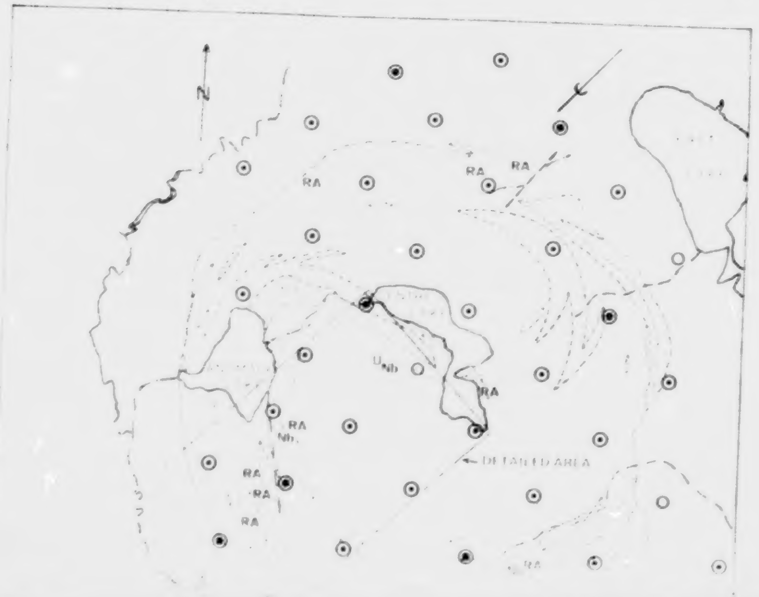


Figure 8 – Geochemical map of nickel in 'B' horizon soils, Prairie Lake area.





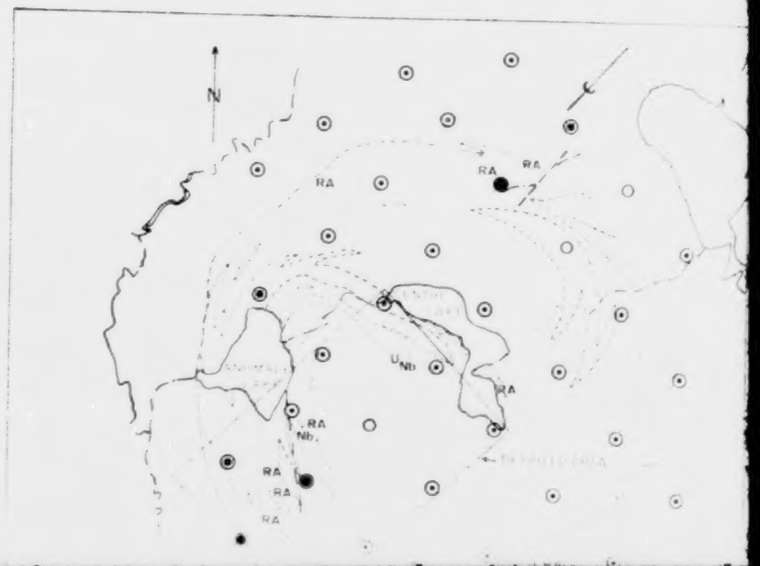


Chart A 1
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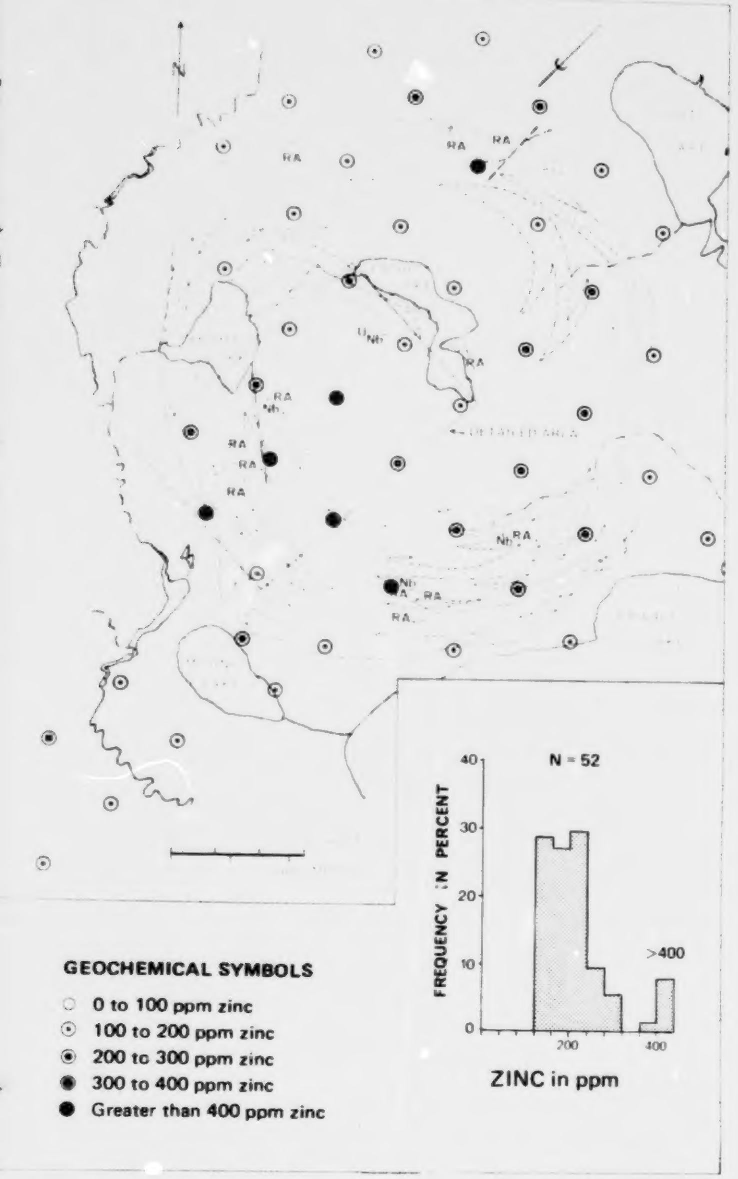


ure 7 – Geochemical map of zinc in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

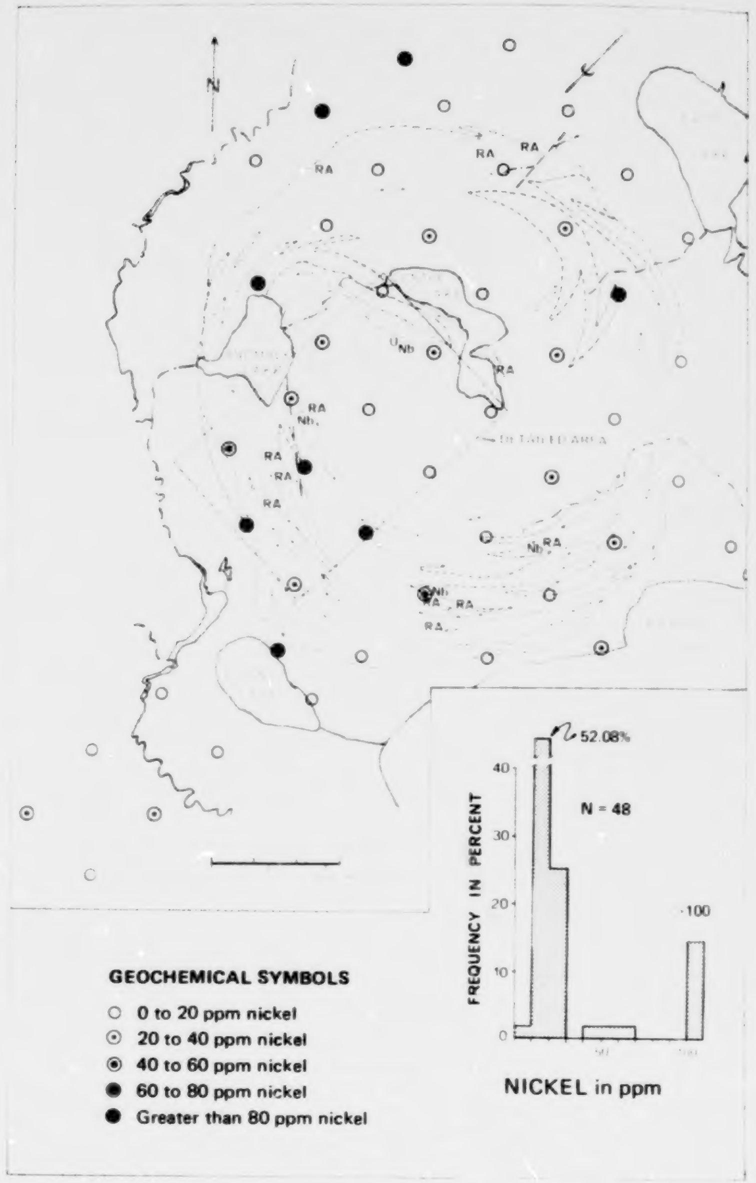


Figure 8 – Geochemical map of nickel in 'B' horizon soils, Prairie Lake area.

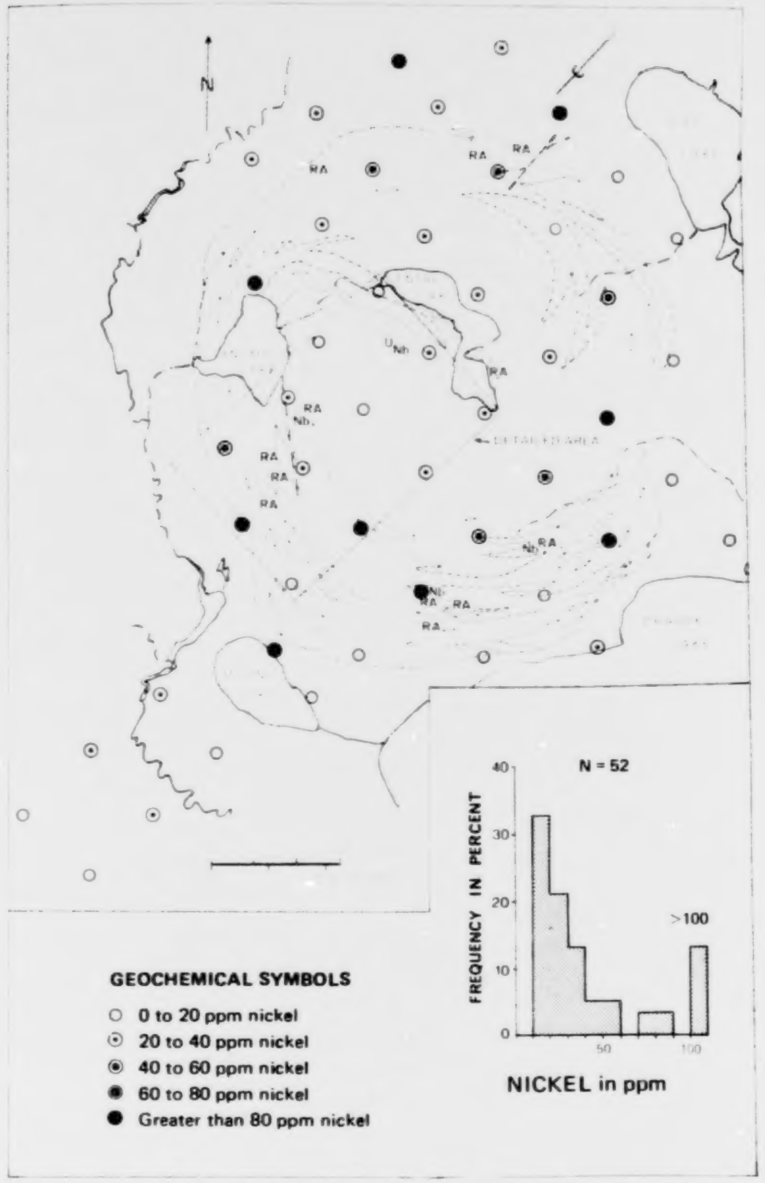


Figure 9 – Geochemical map of nickel in -250 mesh till samples, Prairie Lake area.

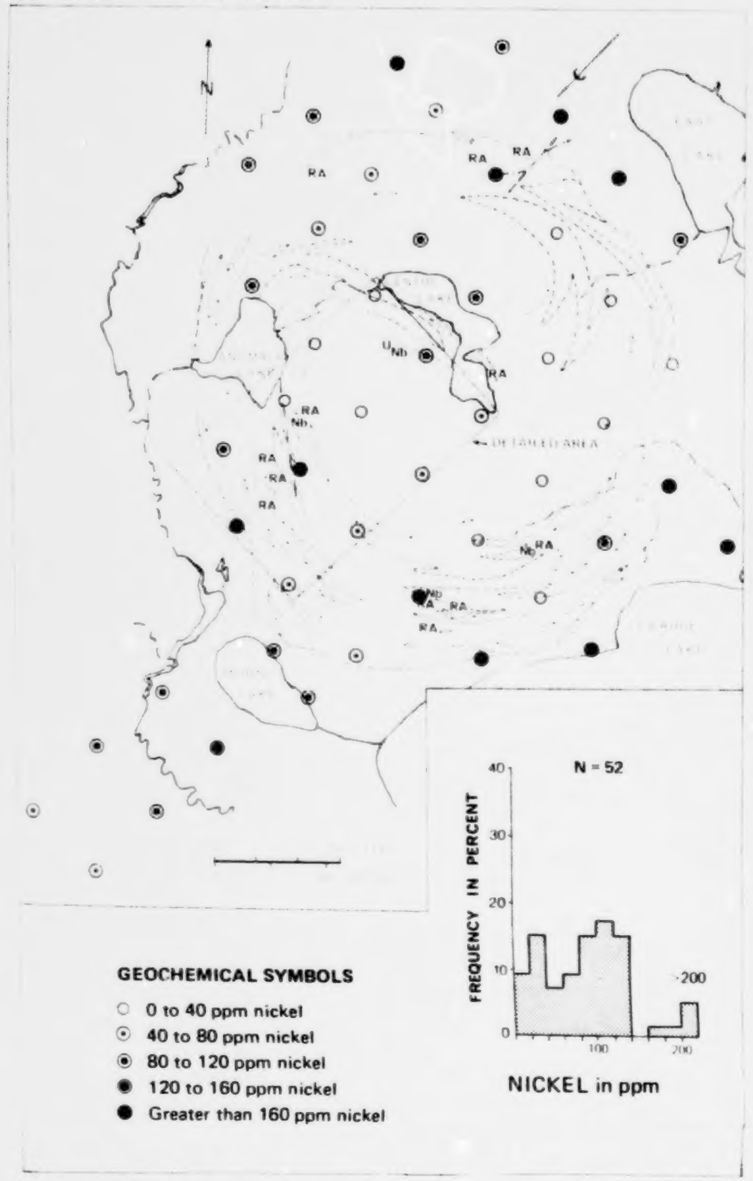


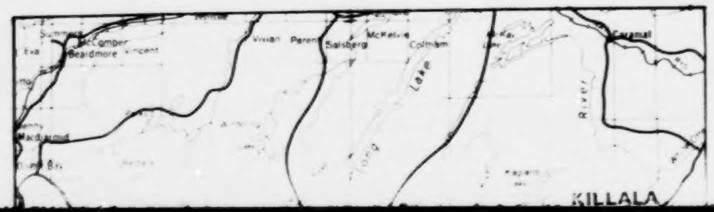
Figure 10 – Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

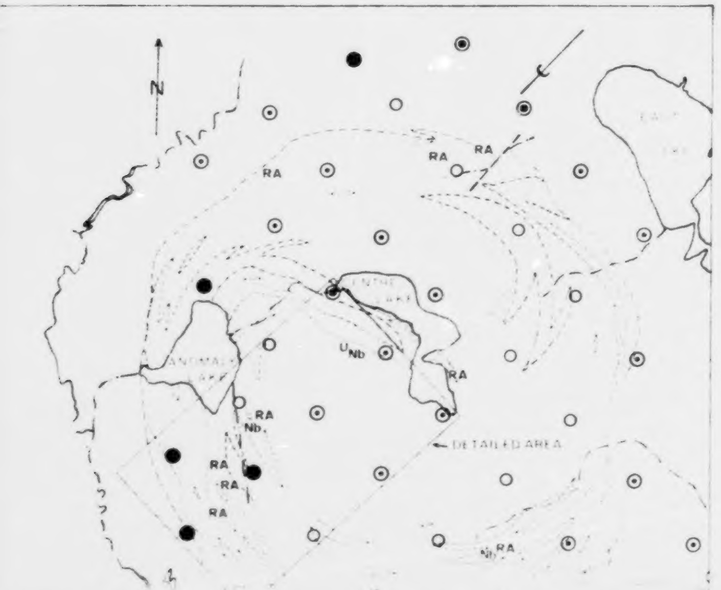
CHART A–1

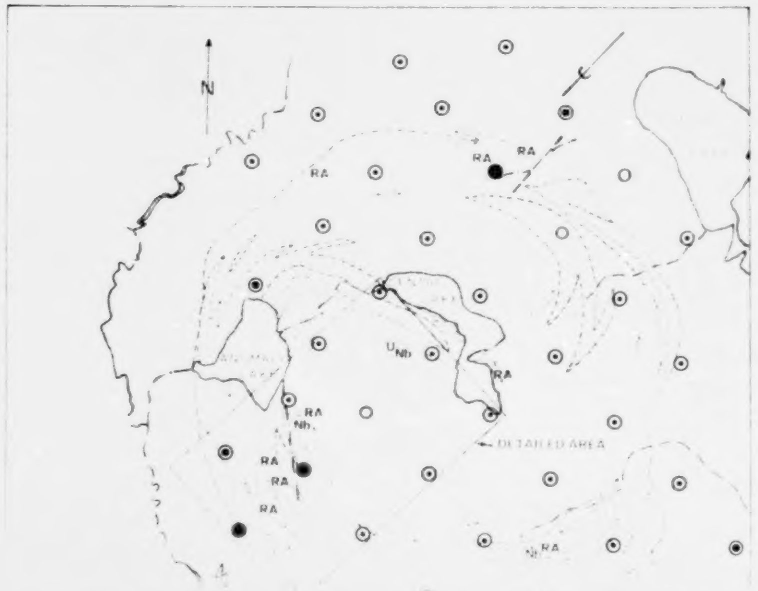
Geochemical Distribution of ZINC, NICKEL, TITANIUM/TITANIA, AND MANGANESE IN OVERBURDEN

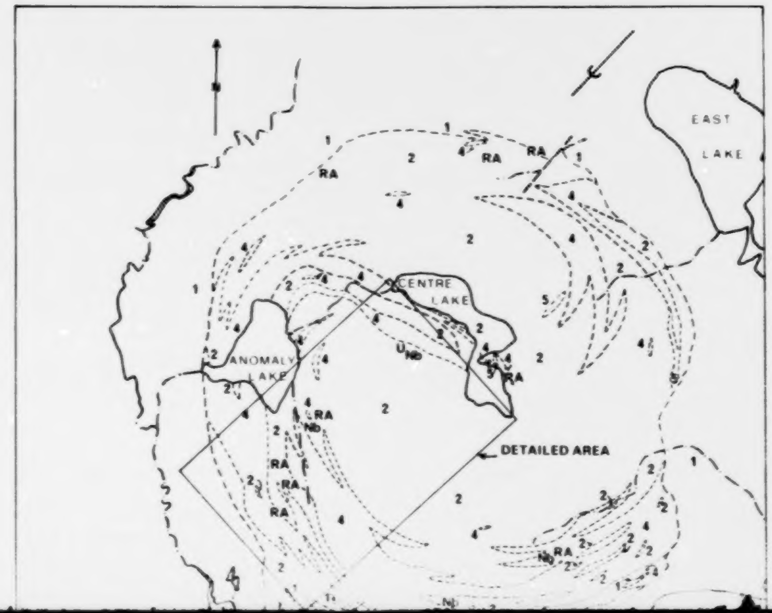
PRAIRIE LAKE AREA

District of Thunder Bay









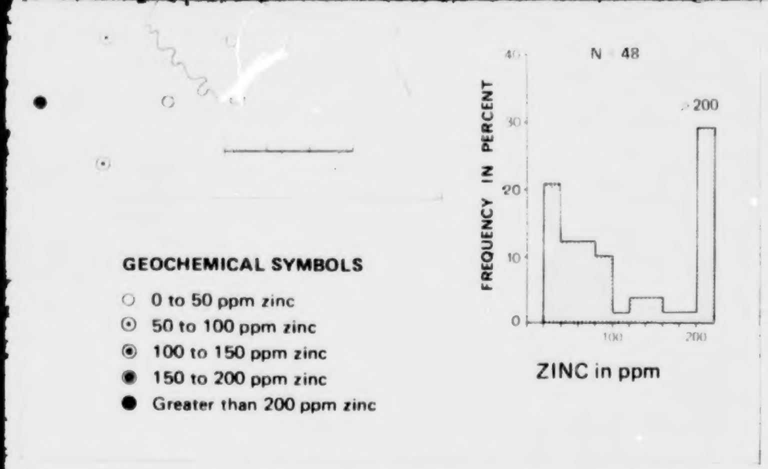


Figure 5 – Geochemical map of zinc in 'B' horizon soils, Prairie Lake area.

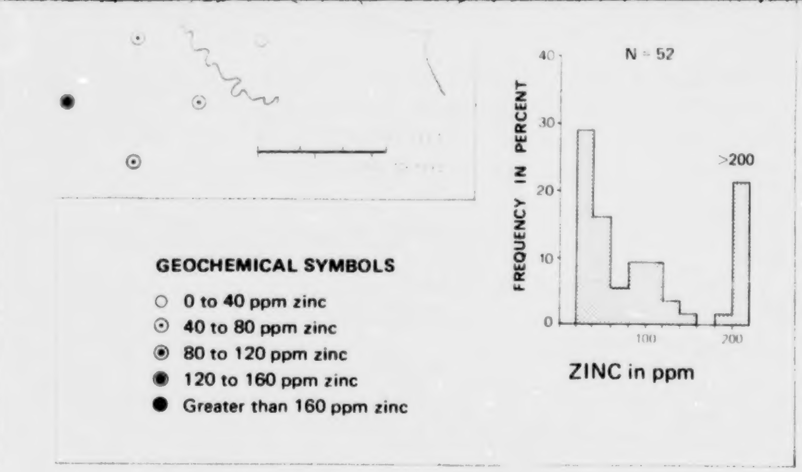


Figure 6 – Geochemical map of zinc in -250 mesh till samples, Prairie Lake area.

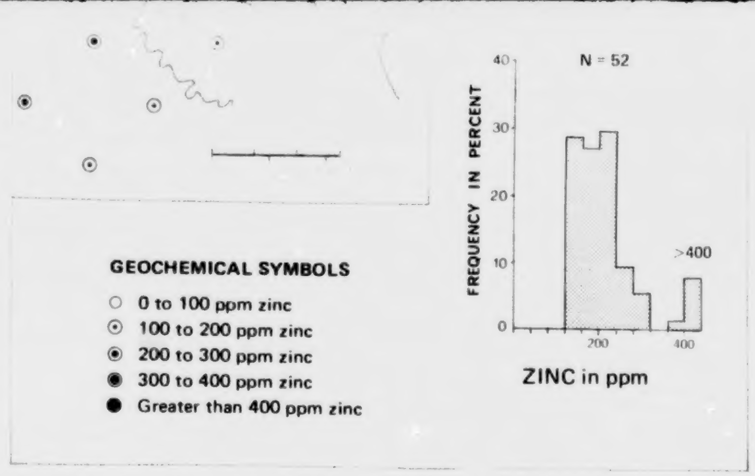


Figure 7 – Geochemical map of zinc in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

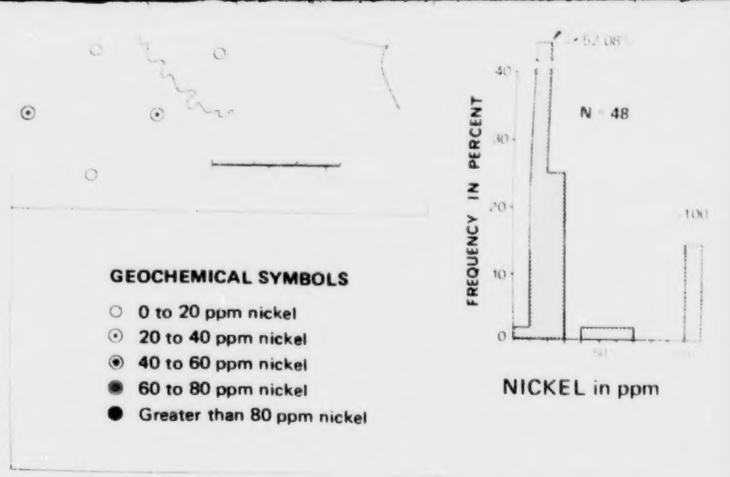


Figure 8 – Geochemical map of nickel in 'B' horizon soils, Prairie Lak area.

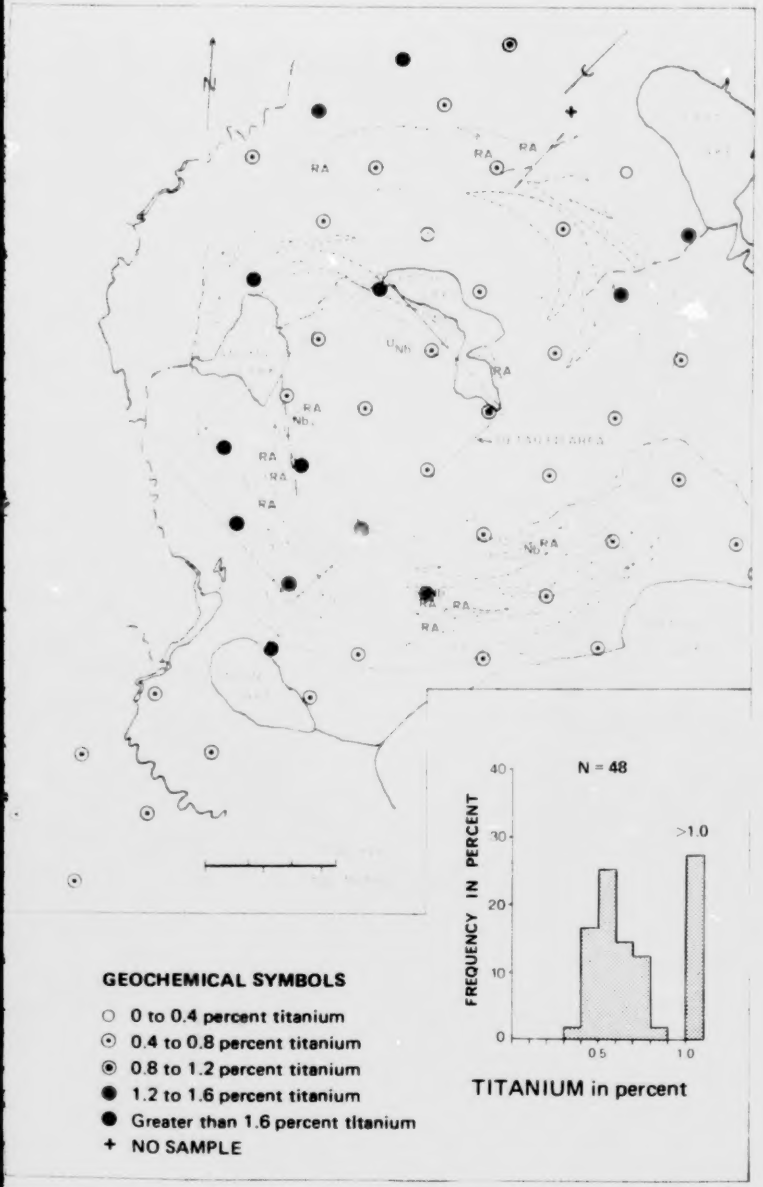

N
RA
Nb
U
N = 48
>1.0
FREQUENCY IN PERCENT
TITANIUM in percent
GEOCHEMICAL SYMBOLS
○ 0 to 0.4 percent titanium
⊙ 0.4 to 0.8 percent titanium
◉ 0.8 to 1.2 percent titanium
● 1.2 to 1.6 percent titanium
● Greater than 1.6 percent titanium
+ NO SAMPLE

Figure 11 – Geochemical map of titanium in 'B' horizon soils, Prairie Lake area.

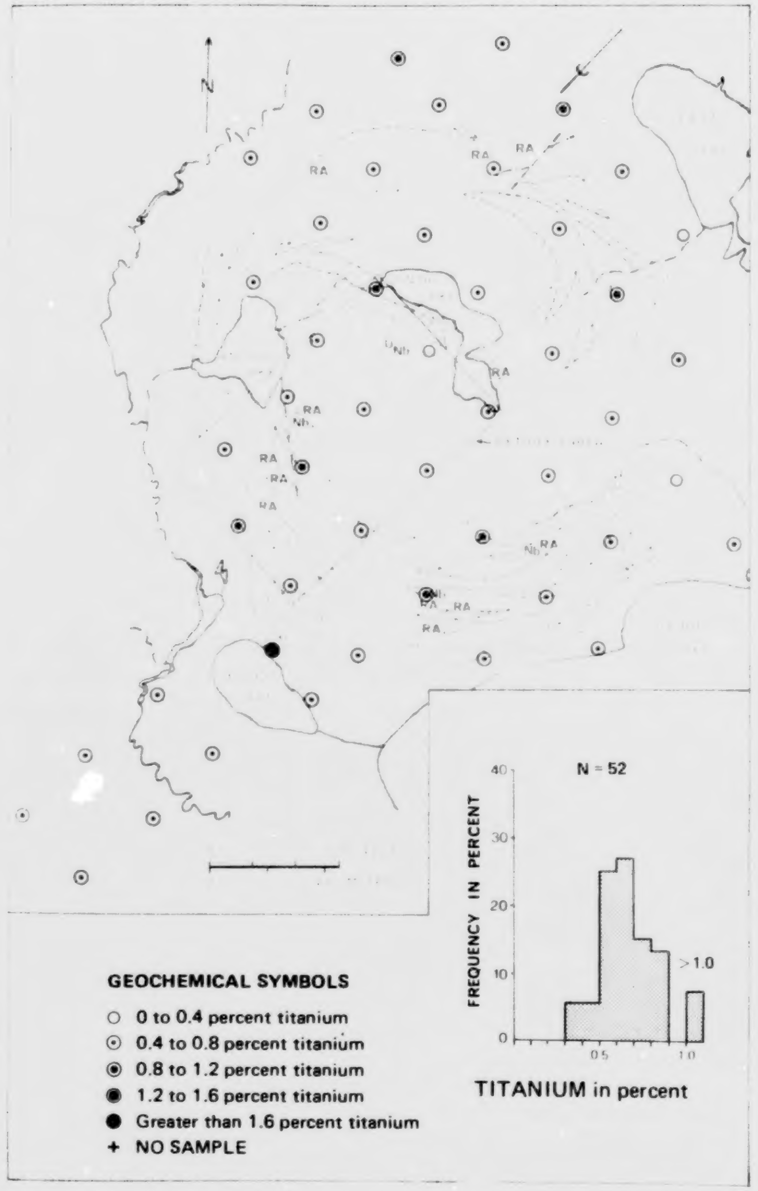

N
RA
Nb
U
N = 52
>1.0
FREQUENCY IN PERCENT
TITANIUM in percent
GEOCHEMICAL SYMBOLS
○ 0 to 0.4 percent titanium
⊙ 0.4 to 0.8 percent titanium
◉ 0.8 to 1.2 percent titanium
● 1.2 to 1.6 percent titanium
● Greater than 1.6 percent titanium
+ NO SAMPLE

Figure 12 – Geochemical map of titanium in -250 mesh till samples, Prairie Lake area.

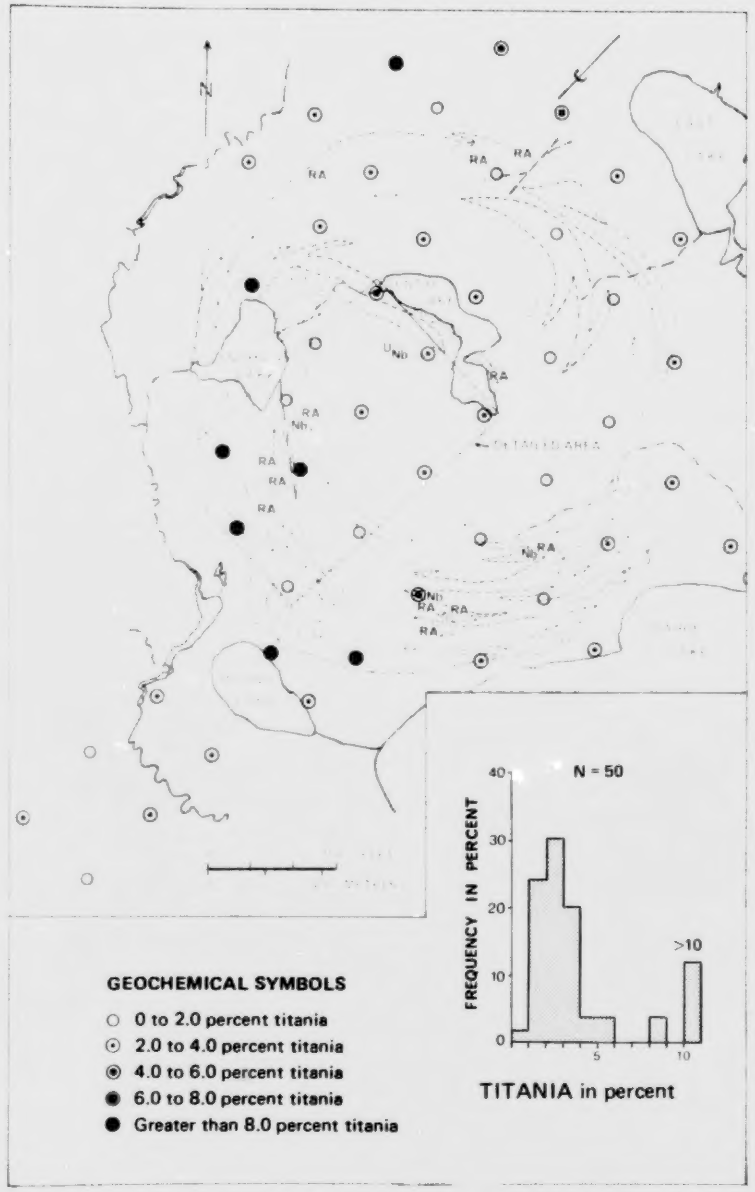

N
RA
Nb
U
N = 50
>10
FREQUENCY IN PERCENT
TITANIA in percent
GEOCHEMICAL SYMBOLS
○ 0 to 2.0 percent titania
⊙ 2.0 to 4.0 percent titania
◉ 4.0 to 6.0 percent titania
● 6.0 to 8.0 percent titania
● Greater than 8.0 percent titania

Figure 13 – Geochemical map of titania in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

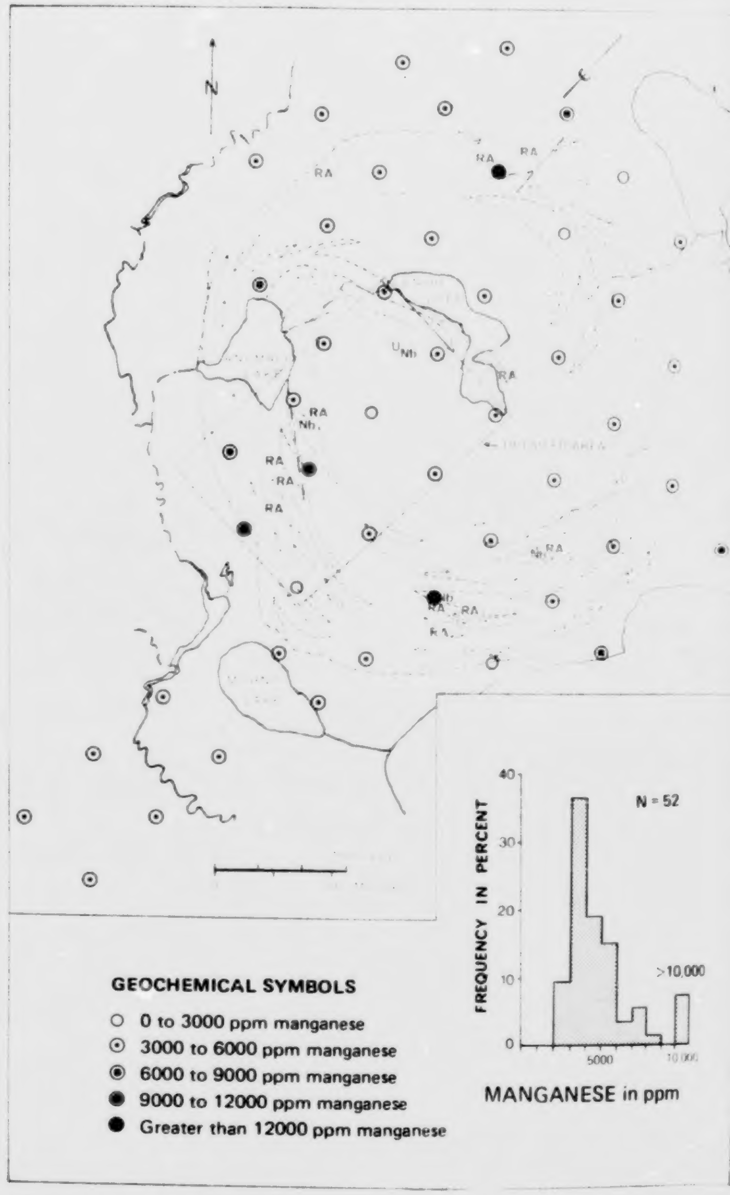
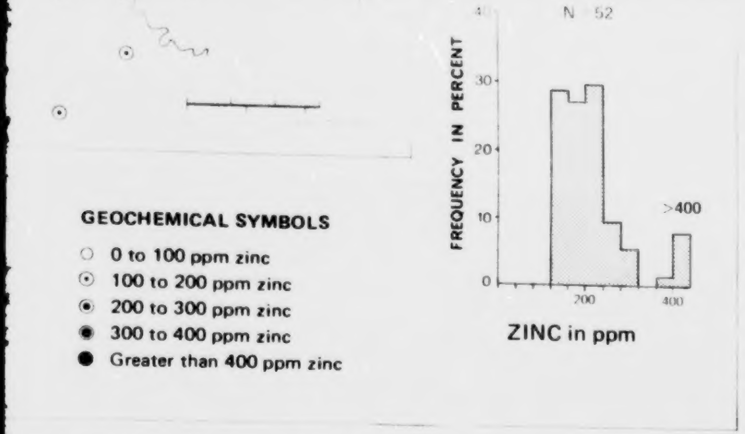

N
RA
Nb
U
N = 52
>10,000
FREQUENCY IN PERCENT
MANGANESE in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 3000 ppm manganese
⊙ 3000 to 6000 ppm manganese
◉ 6000 to 9000 ppm manganese
● 9000 to 12000 ppm manganese
● Greater than 12000 ppm manganese

Figure 14 – Geochemical map of manganese in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.



gure 7 – Geochemical map of zinc in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

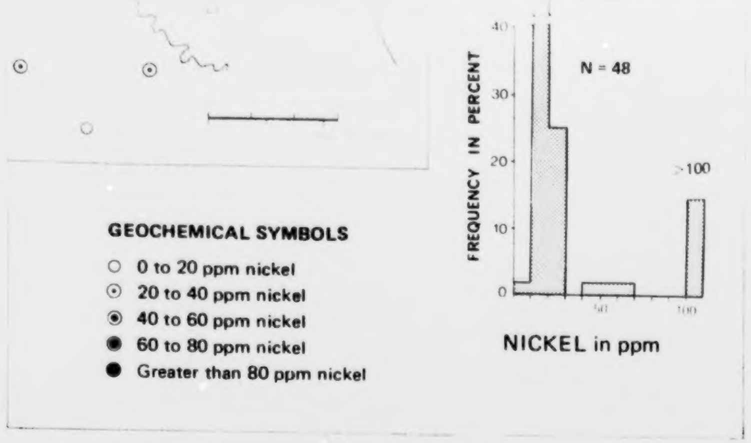


Figure 8 – Geochemical map of nickel in 'B' horizon soils, Prairie Lake area.

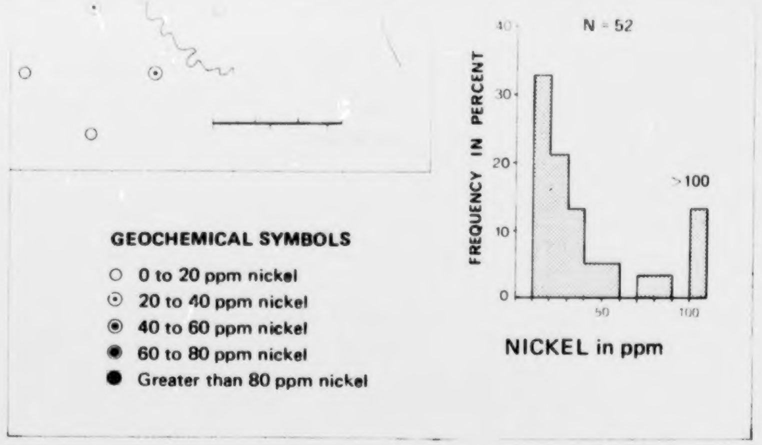


Figure 9 – Geochemical map of nickel in -250 mesh till samples, Prairie Lake area.

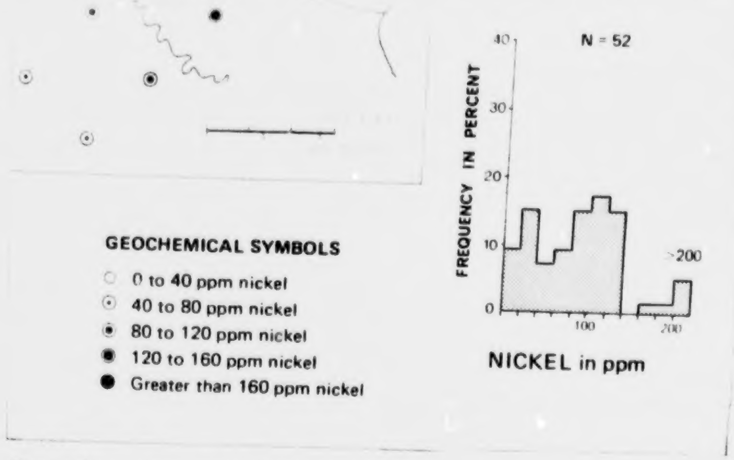
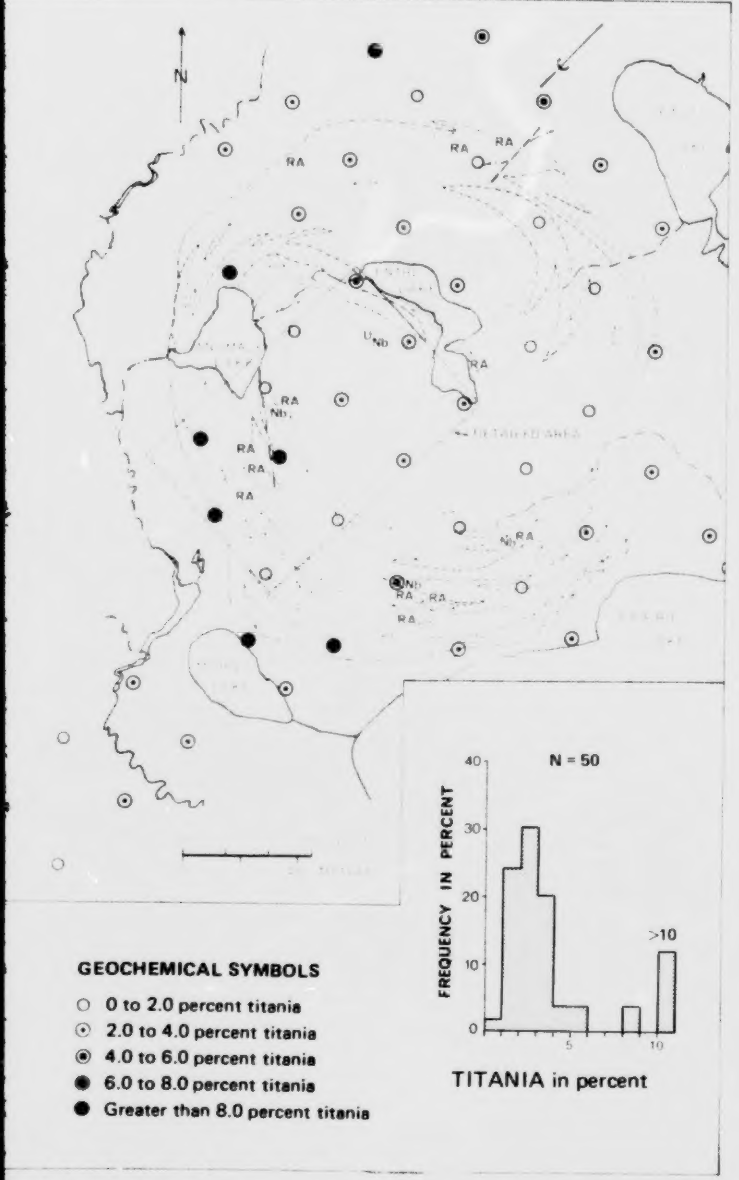


Figure 10 – Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.


N
RA
U
Nb
N = 50
FREQUENCY IN PERCENT
TITANIA in percent
>10
GEOCHEMICAL SYMBOLS
○ 0 to 2.0 percent titania
⊙ 2.0 to 4.0 percent titania
◉ 4.0 to 6.0 percent titania
● 6.0 to 8.0 percent titania
● Greater than 8.0 percent titania

ure 13 – Geochemical map of titania in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

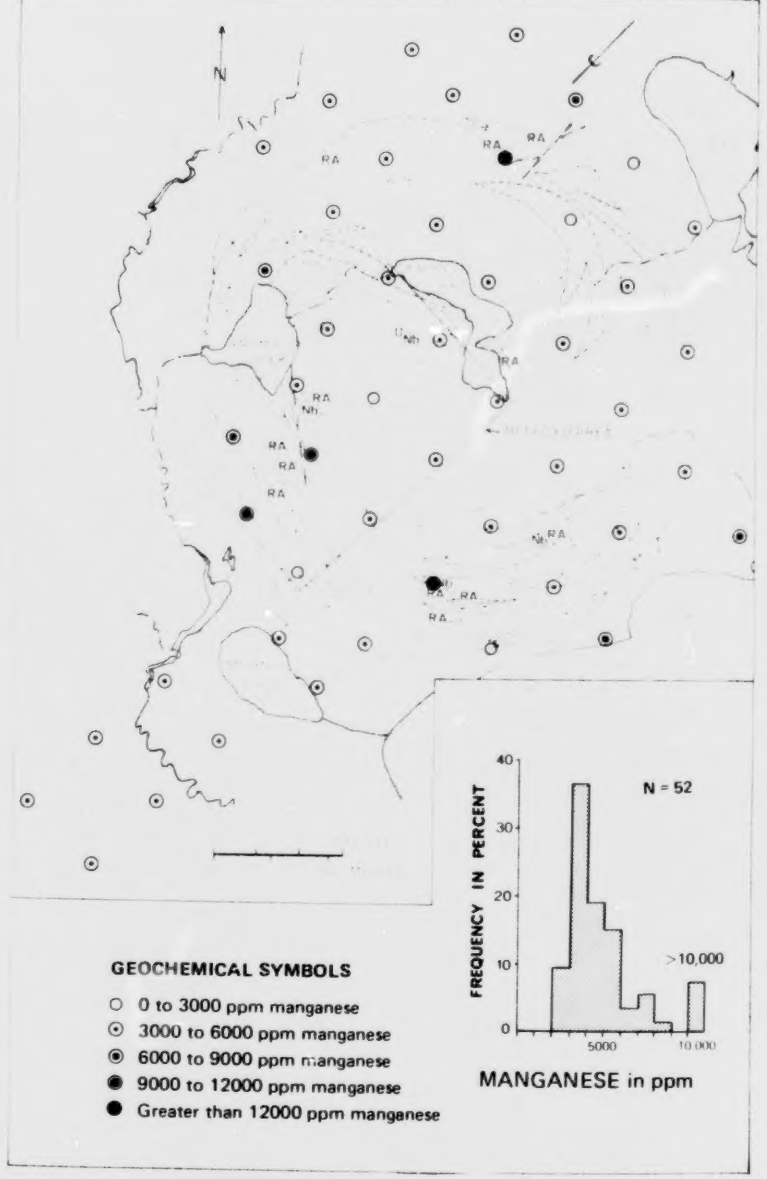

N
RA
U
Nb
N = 52
FREQUENCY IN PERCENT
MANGANESE in ppm
>10,000
GEOCHEMICAL SYMBOLS
○ 0 to 3000 ppm manganese
⊙ 3000 to 6000 ppm manganese
◉ 6000 to 9000 ppm manganese
● 9000 to 12000 ppm manganese
● Greater than 12000 ppm manganese

Figure 14 – Geochemical map of manganese in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

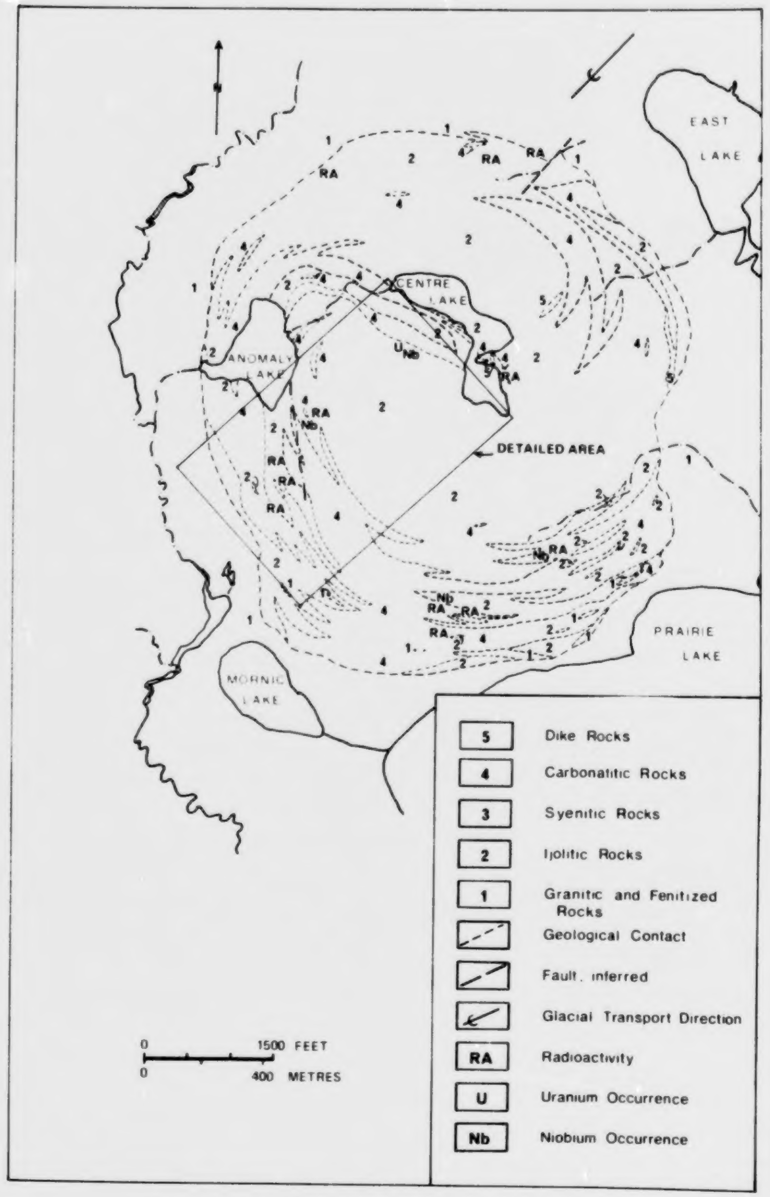


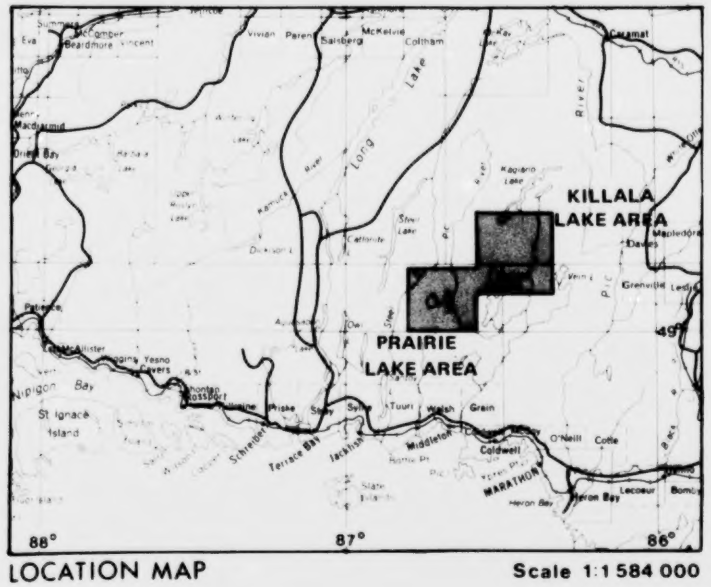
Figure 15 – Bedrock geology, Prairie Lake area.

CHART A–1

Geochemical Distribution of ZINC, NICKEL, TITANIUM/TITANIA, AND MANGANESE IN OVERBURDEN

PRAIRIE LAKE AREA

District of Thunder Bay



LOCATION MAP Scale 1:1 584 000

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from unpublished geological map prepared for Newmont Mining Corporation of Canada Limited.

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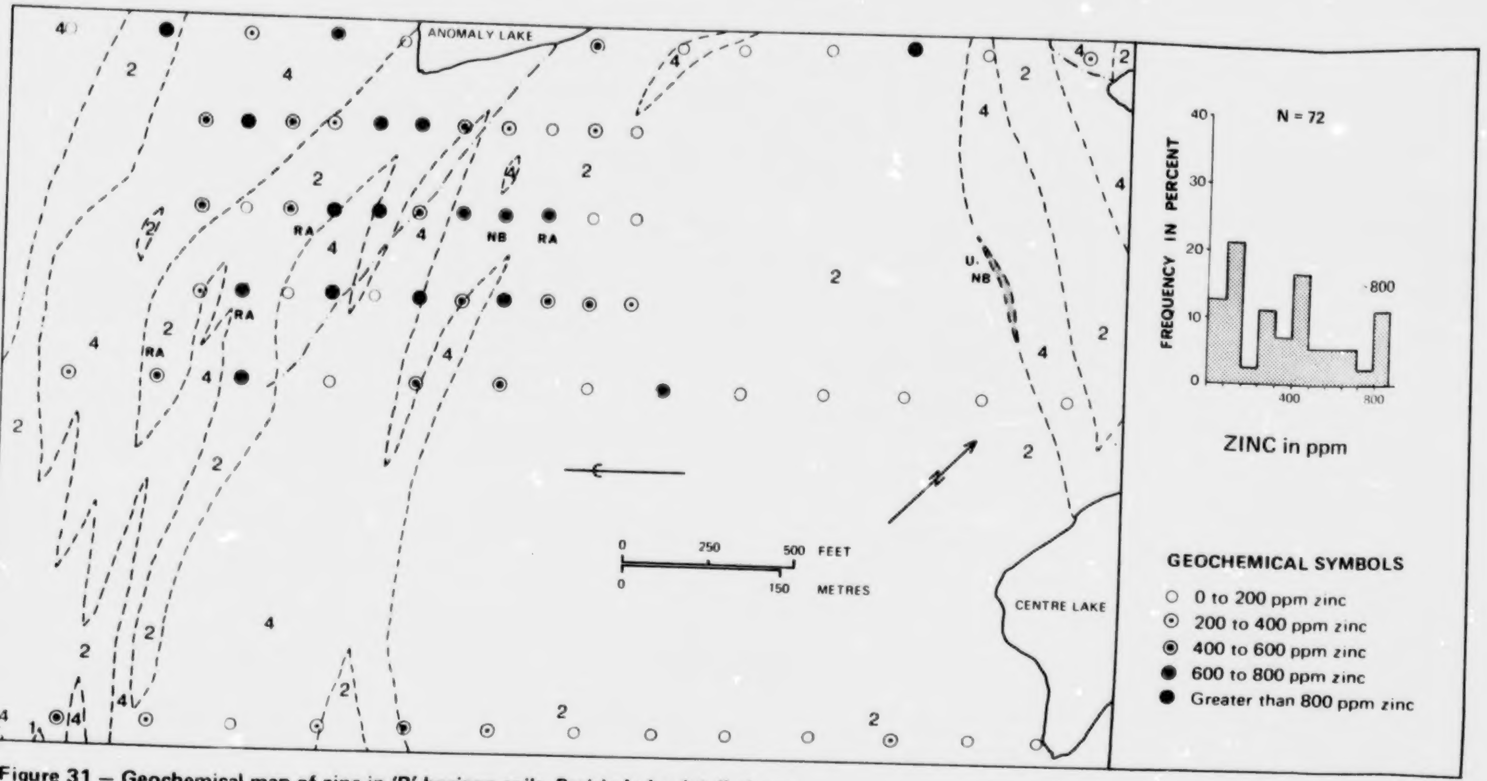


Figure 31 – Geochemical map of zinc in 'B' horizon soils, Prairie Lake detailed area.

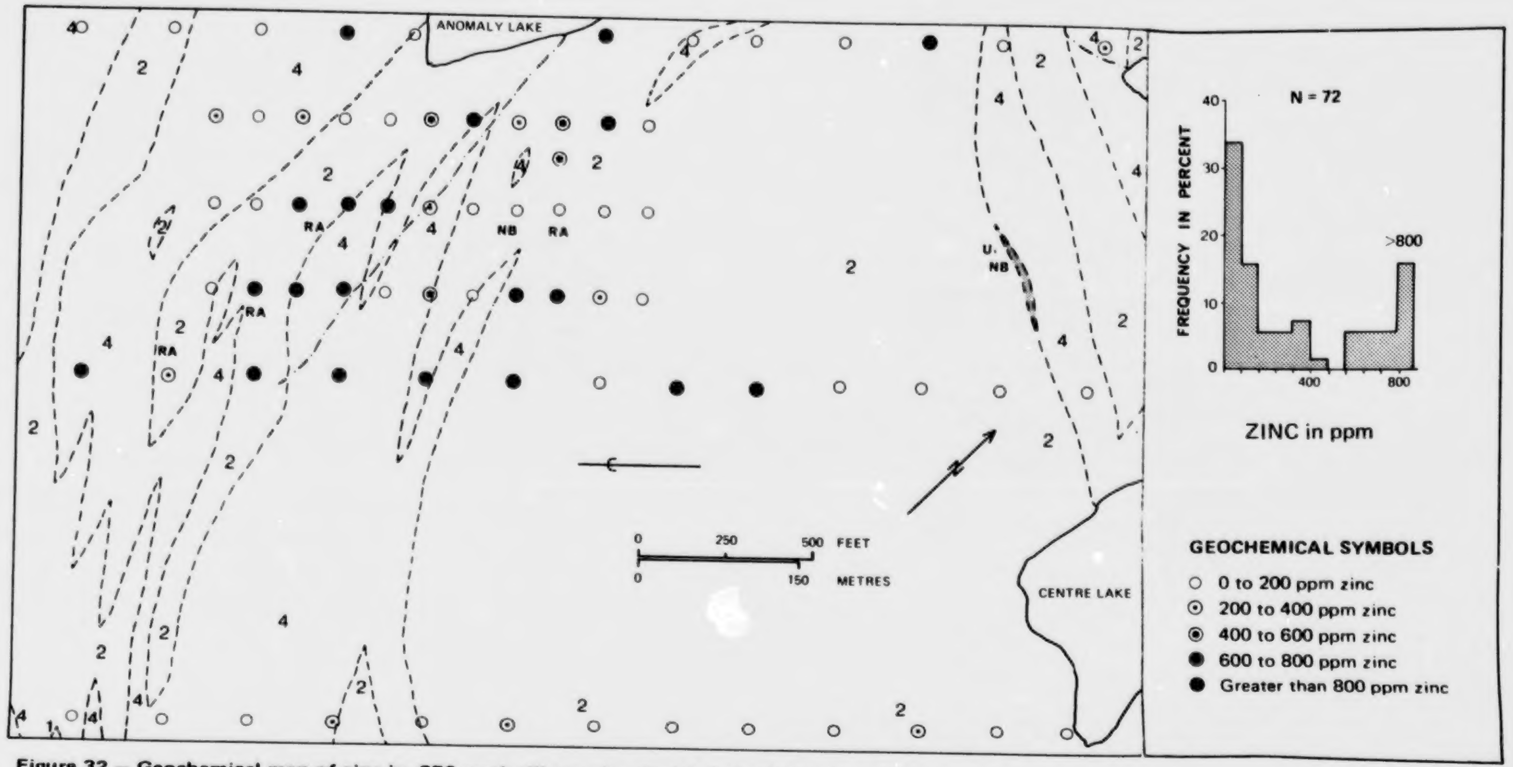


Figure 32 – Geochemical map of zinc in -250 mesh till samples, Prairie Lake detailed area.

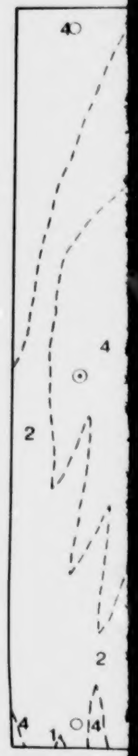


Figure 33

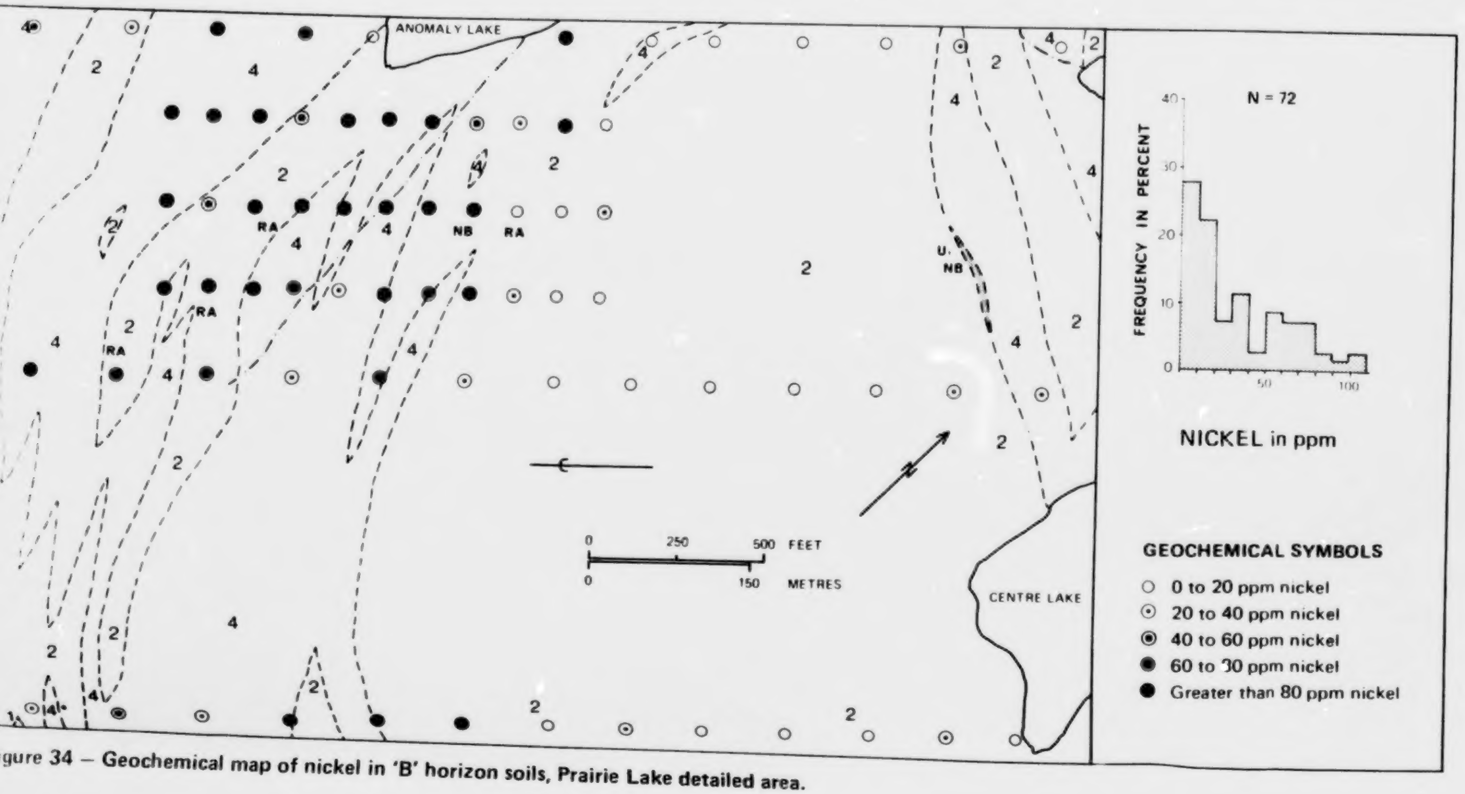


Figure 34 – Geochemical map of nickel in 'B' horizon soils, Prairie Lake detailed area.

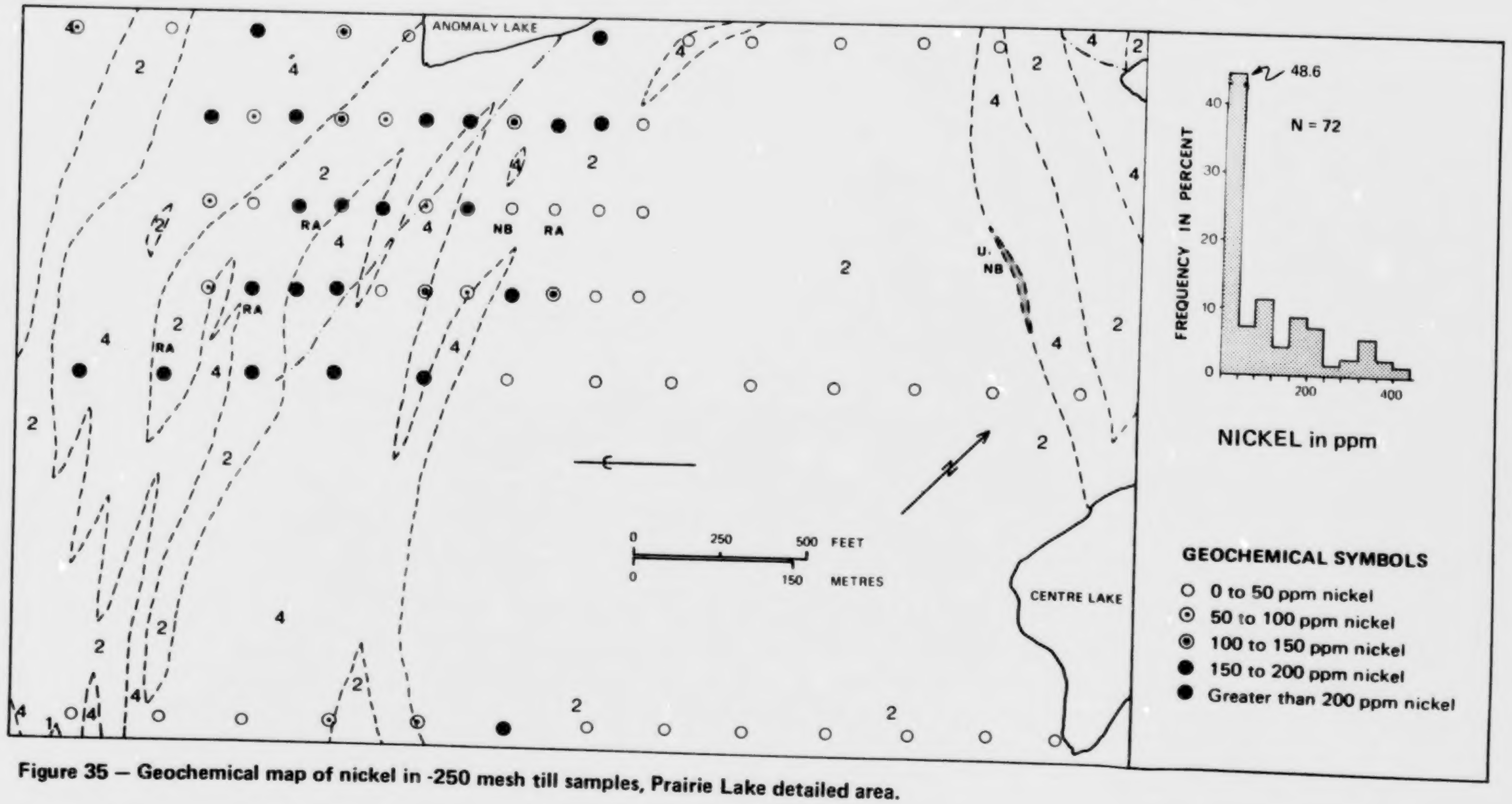
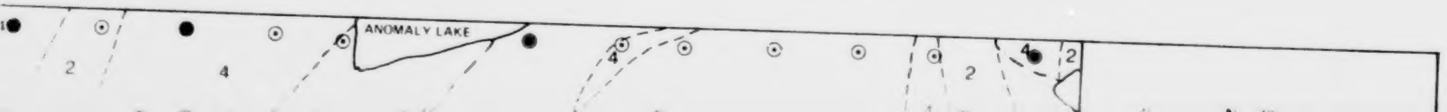
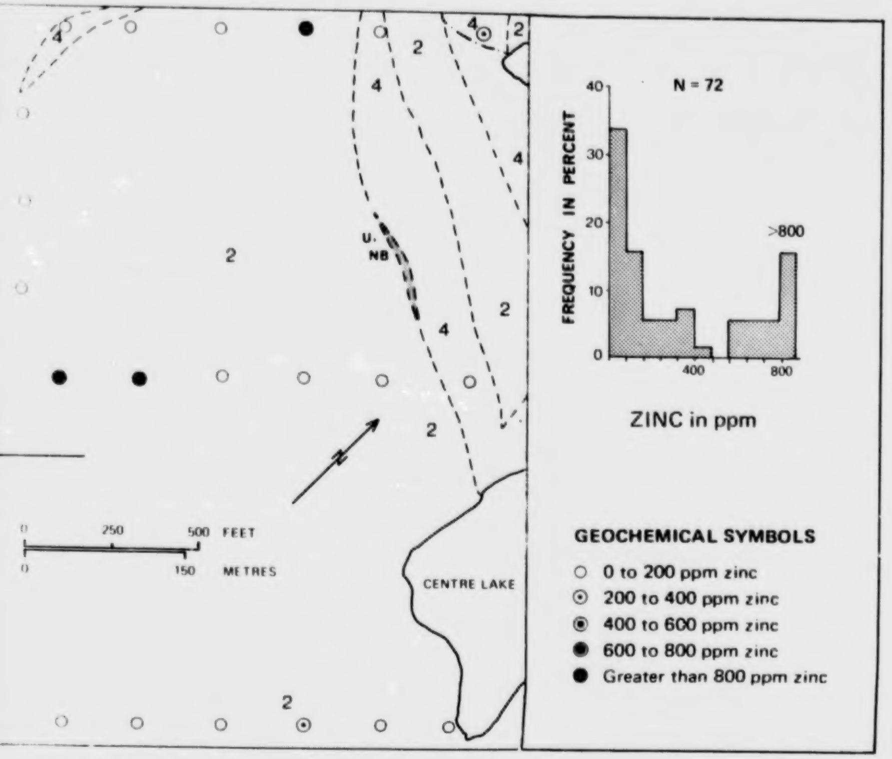


Figure 35 – Geochemical map of nickel in -250 mesh till samples, Prairie Lake detailed area.

Figure 36 –



Orientation Overburden Geochemistry and Quaternary Geology Investigations of Carbonatite Alkalic Complexes at Prairie Lake and Killala Lake.
Chart B-1
Figures 31 to 42 (inclusive)



es, Prairie Lake detailed area.

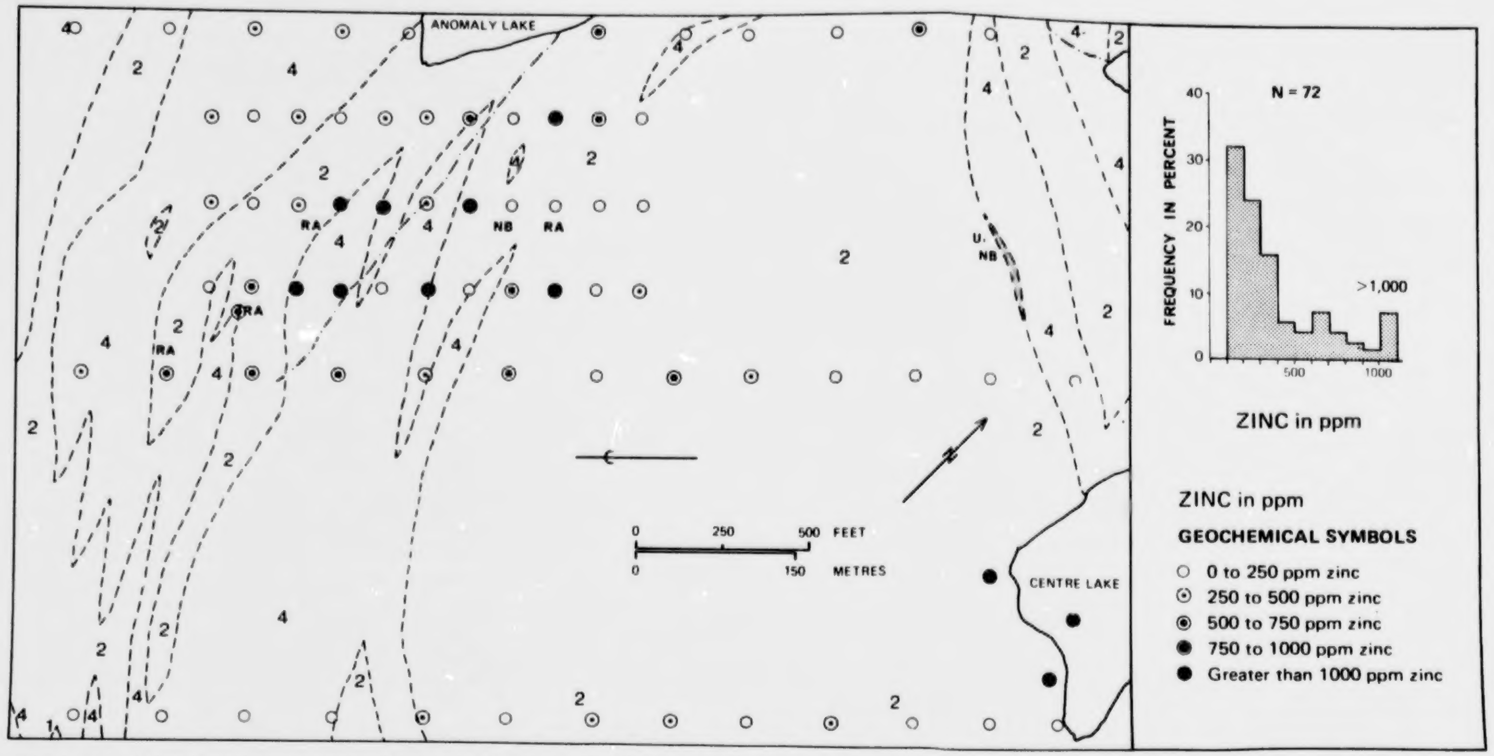


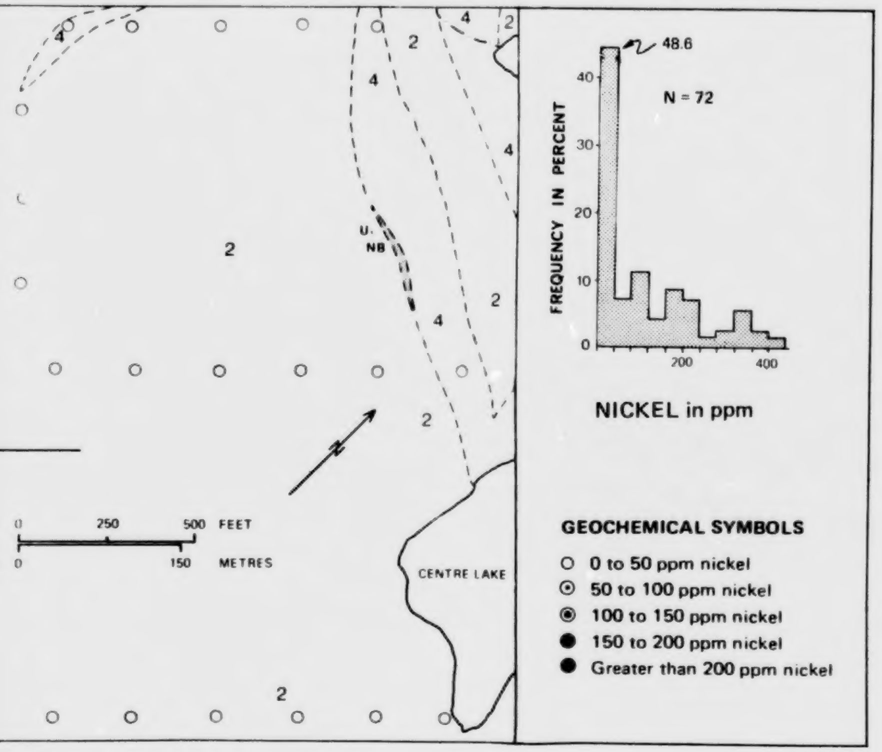
Figure 33 — Geochemical map of zinc in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.

CHART B-1

Geochemical Distribution of ZINC, NICKEL, TITANIUM/TITANIA, AND PHOSPHORUS IN OVERBURDEN

PRAIRIE LAKE DETAILED AREA

District of Thunder Bay



les, Prairie Lake detailed area.

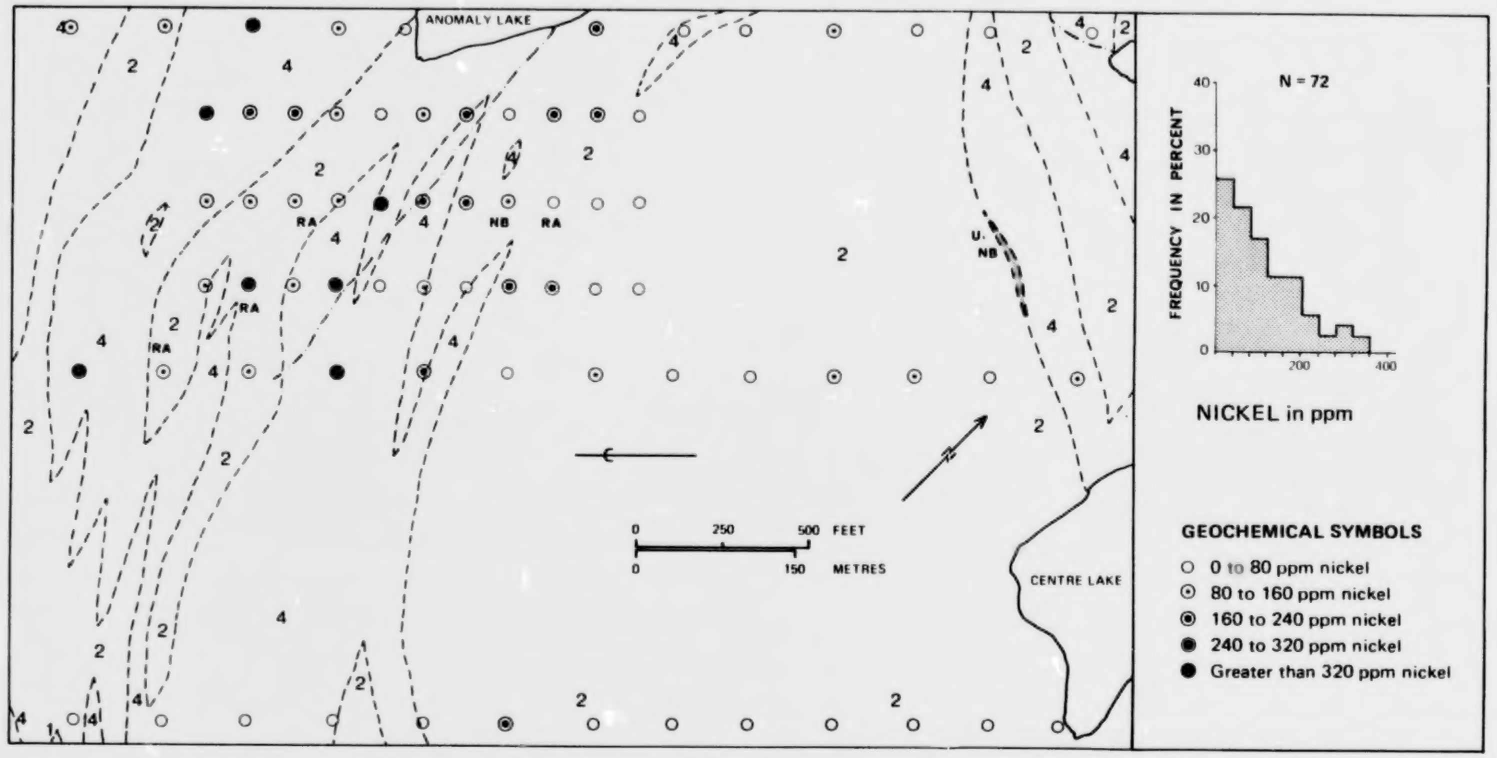
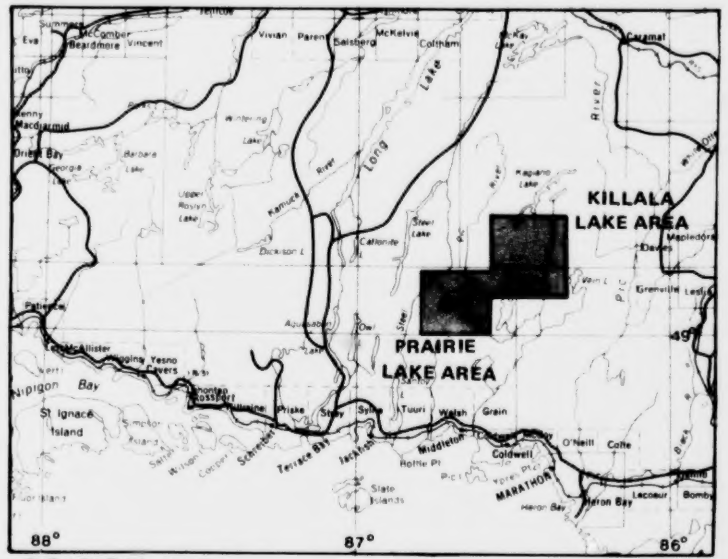


Figure 36 — Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.



LOCATION MAP

Scale 1:1 584 000

LEGEND

5	Dike Rocks
4	Carbonatitic Rocks
3	Syenitic Rocks

Figure 34 – Geochemical map of nickel in 'B' horizon soils, Prairie Lake detailed area.

Figure 35 – Geochemical map of nickel in -250 mesh till samples, Prairie Lake detailed area.

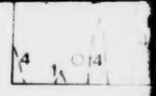


Figure 36 –

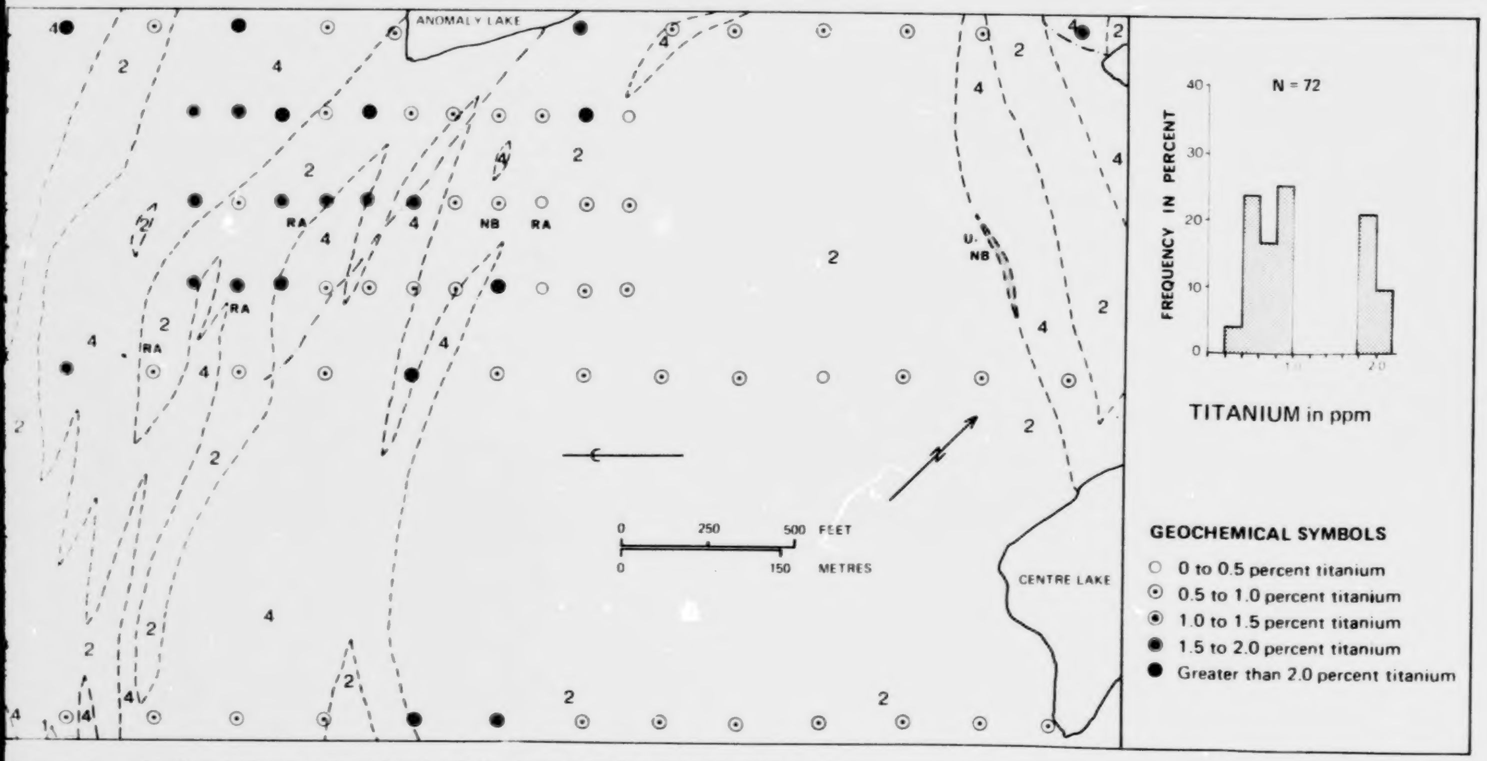

ANOMALY LAKE
RA
NB
U-NB
CENTRE LAKE
0 250 500 FEET
0 150 METRES
N = 72
FREQUENCY IN PERCENT
TITANIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.5 percent titanium
⊙ 0.5 to 1.0 percent titanium
◉ 1.0 to 1.5 percent titanium
● 1.5 to 2.0 percent titanium
● Greater than 2.0 percent titanium

Figure 37 – Geochemical map of titanium in 'B' horizon soils, Prairie Lake detailed area.

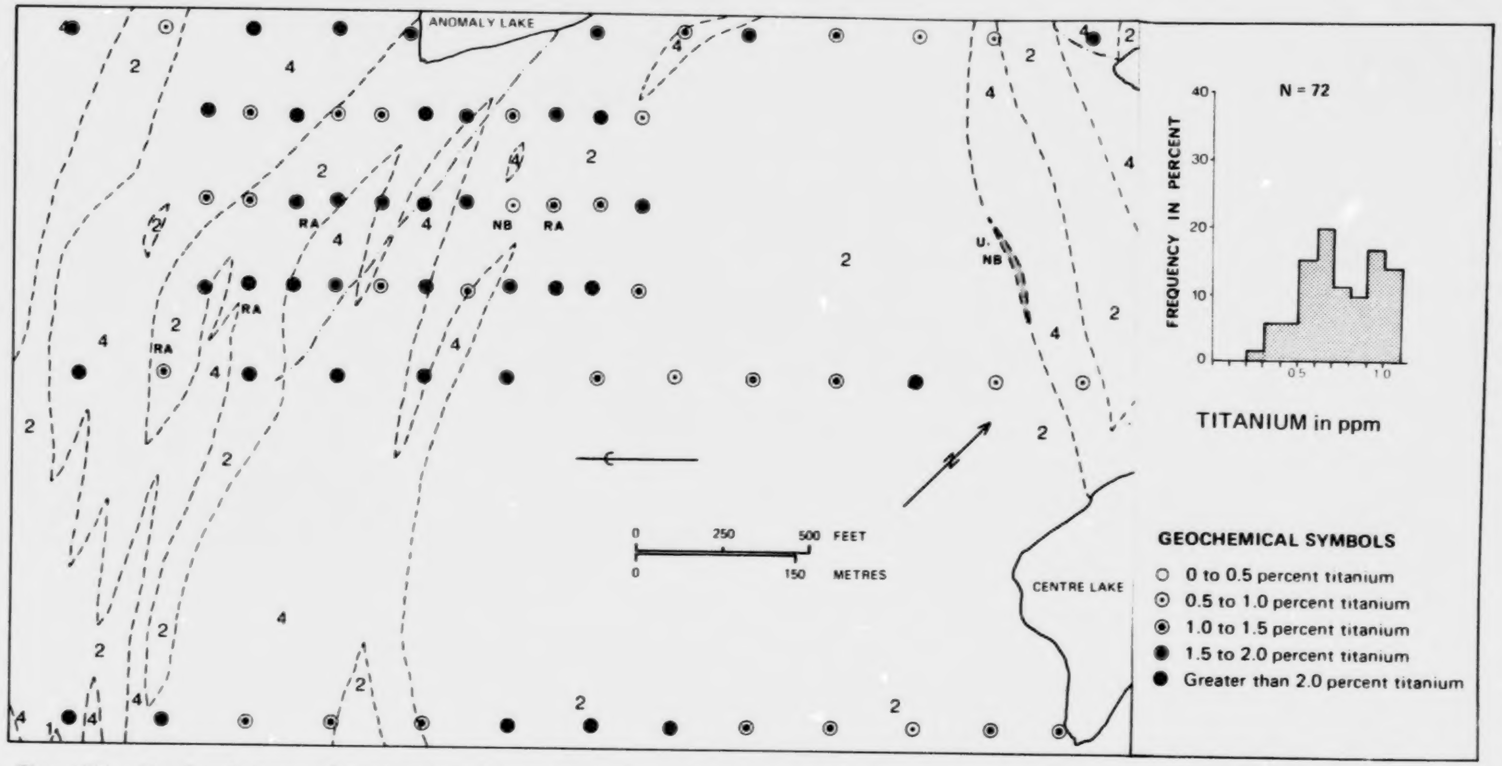

ANOMALY LAKE
RA
NB
U-NB
CENTRE LAKE
0 250 500 FEET
0 150 METRES
N = 72
FREQUENCY IN PERCENT
TITANIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.5 percent titanium
⊙ 0.5 to 1.0 percent titanium
◉ 1.0 to 1.5 percent titanium
● 1.5 to 2.0 percent titanium
● Greater than 2.0 percent titanium

Figure 38 – Geochemical map of titanium in -250 mesh till samples, Prairie Lake detailed area.

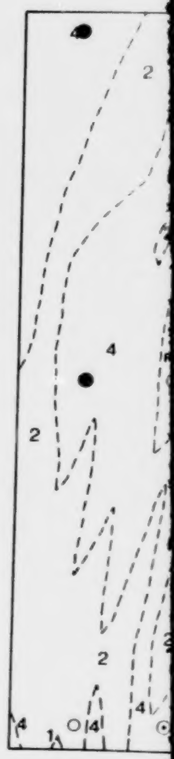


Figure 39 – Ge

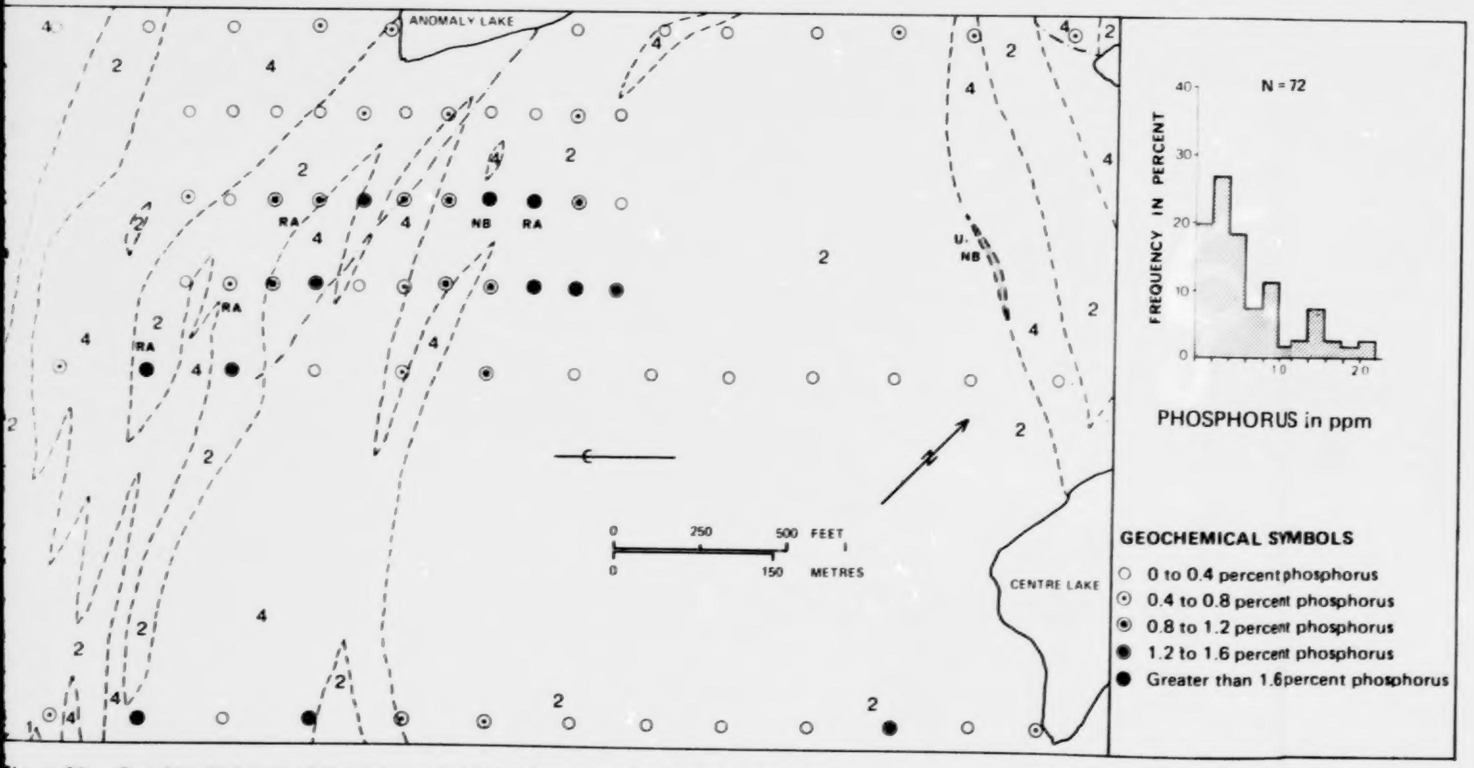

ANOMALY LAKE
RA
NB
U-NB
CENTRE LAKE
0 250 500 FEET
0 150 METRES
N = 72
FREQUENCY IN PERCENT
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.4 percent phosphorus
⊙ 0.4 to 0.8 percent phosphorus
◉ 0.8 to 1.2 percent phosphorus
● 1.2 to 1.6 percent phosphorus
● Greater than 1.6percent phosphorus

Figure 40 – Geochemical map of phosphorus in 'B' horizon soils, Prairie Lake detailed area.

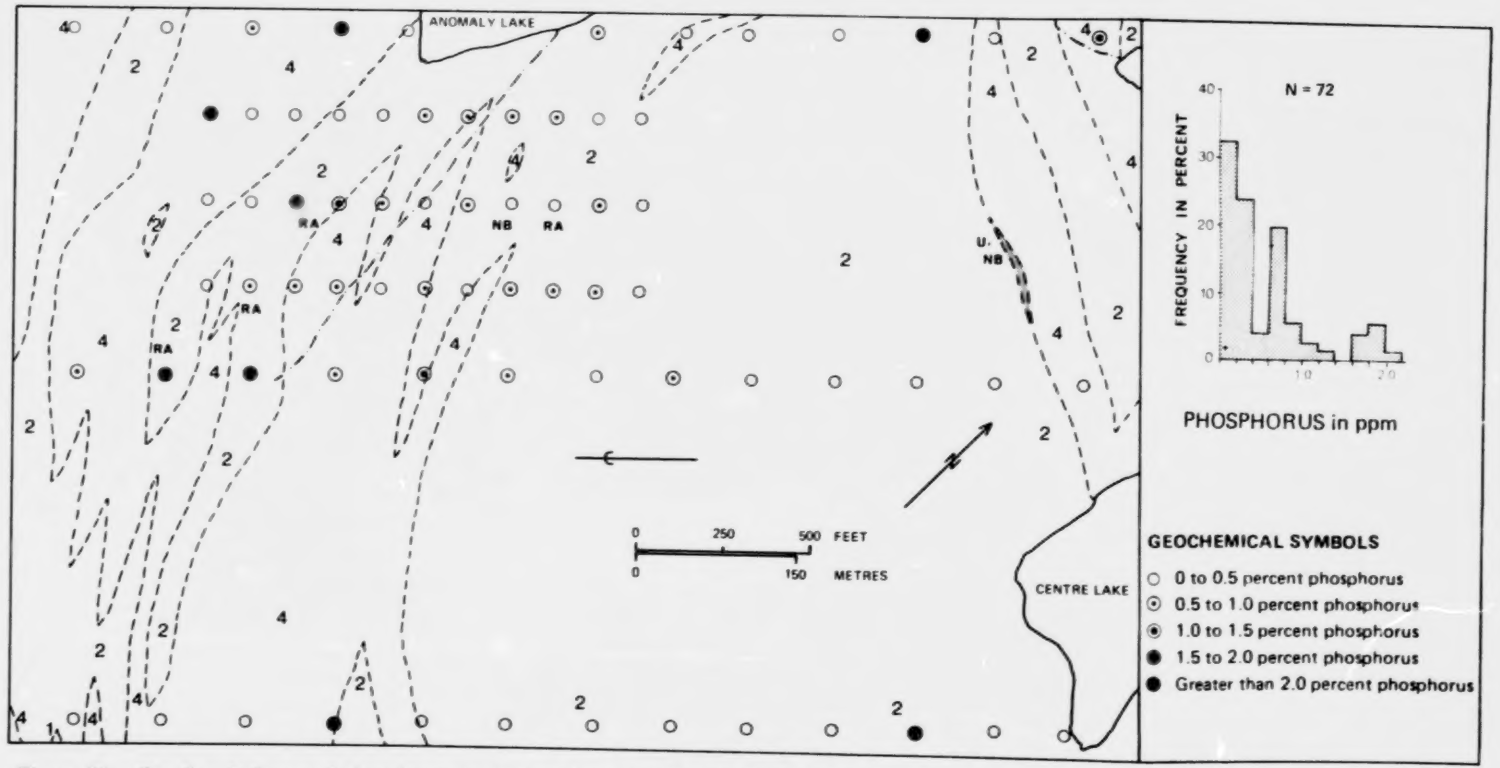

ANOMALY LAKE
RA
NB
U-NB
CENTRE LAKE
0 250 500 FEET
0 150 METRES
N = 72
FREQUENCY IN PERCENT
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.5 percent phosphorus
⊙ 0.5 to 1.0 percent phosphorus
◉ 1.0 to 1.5 percent phosphorus
● 1.5 to 2.0 percent phosphorus
● Greater than 2.0 percent phosphorus

Figure 41 – Geochemical map of phosphorus in -250 mesh till samples, Prairie Lake detailed area.

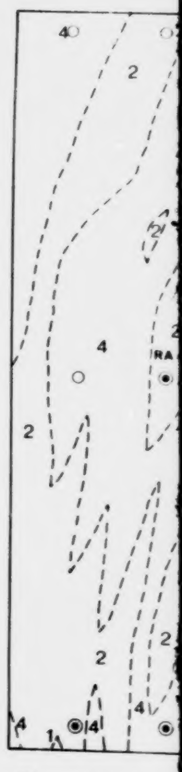
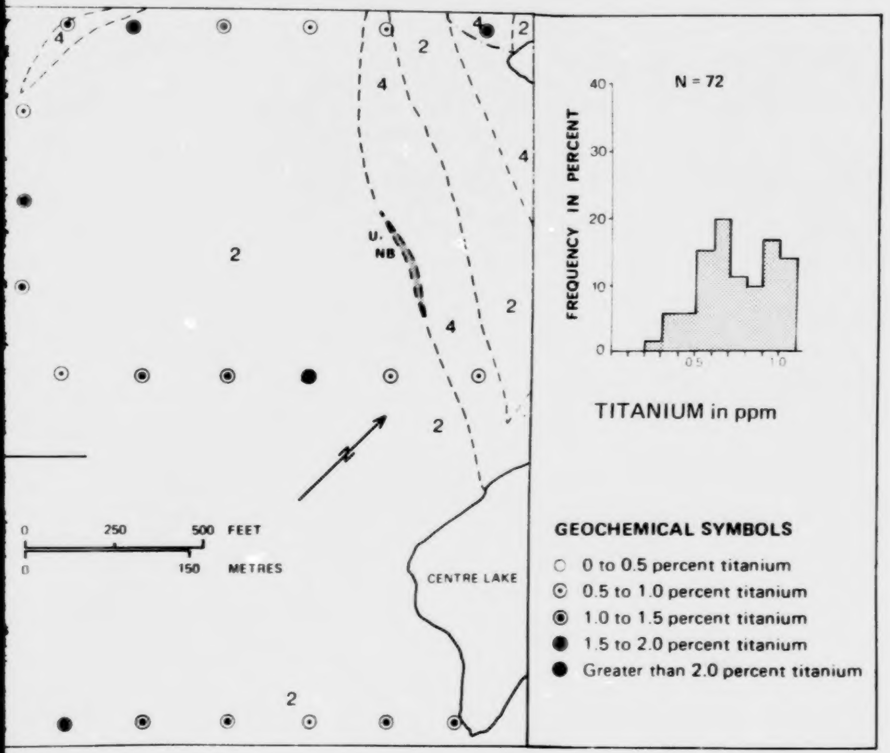


Figure 42 –

les, Prairie Lake detailed area.

Figure 36 – Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.


N = 72
FREQUENCY IN PERCENT
0
10
20
30
40
TITANIUM in ppm
0
250
500 FEET
150 METRES
U.
NB
CENTRE LAKE
GEOCHEMICAL SYMBOLS
○ 0 to 0.5 percent titanium
⊙ 0.5 to 1.0 percent titanium
◉ 1.0 to 1.5 percent titanium
● 1.5 to 2.0 percent titanium
● Greater than 2.0 percent titanium

mples, Prairie Lake detailed area.

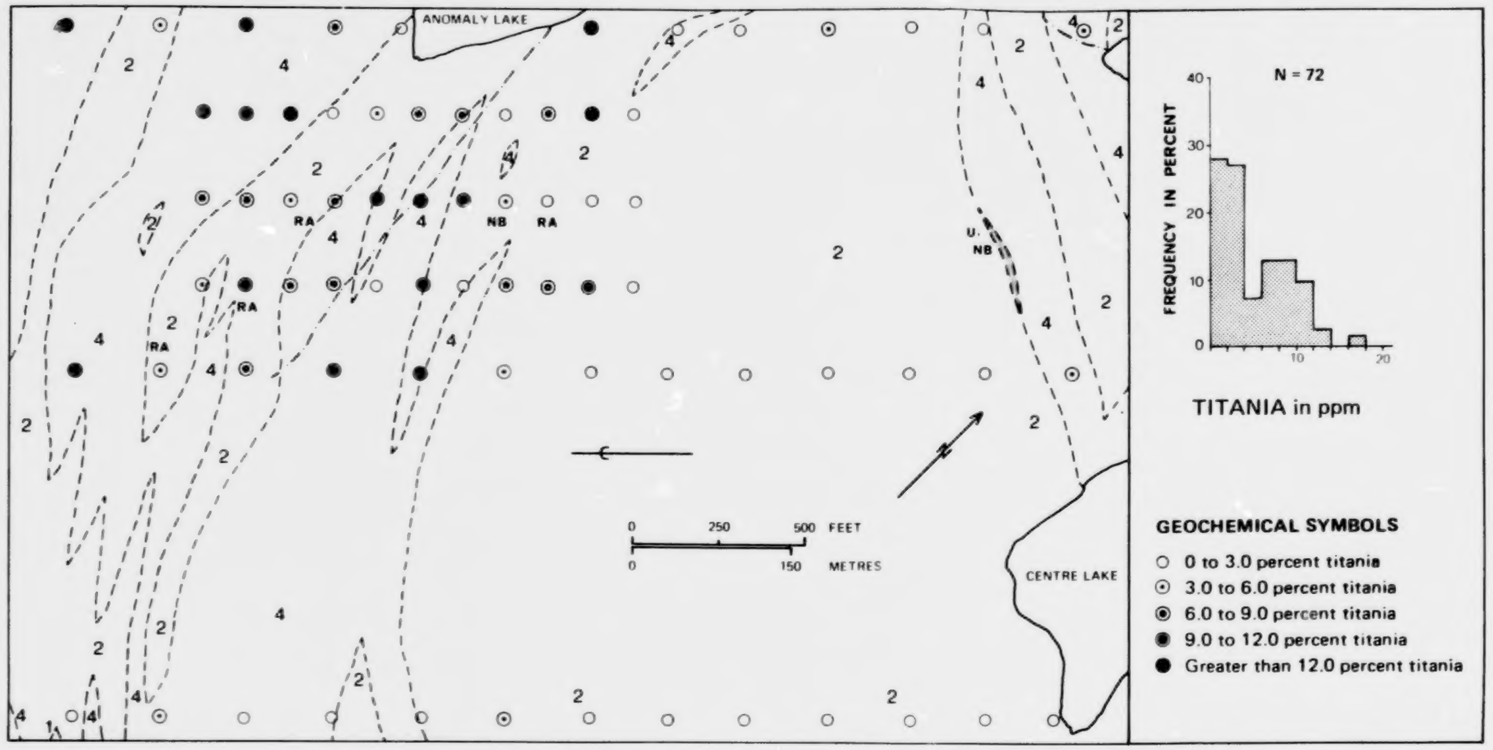
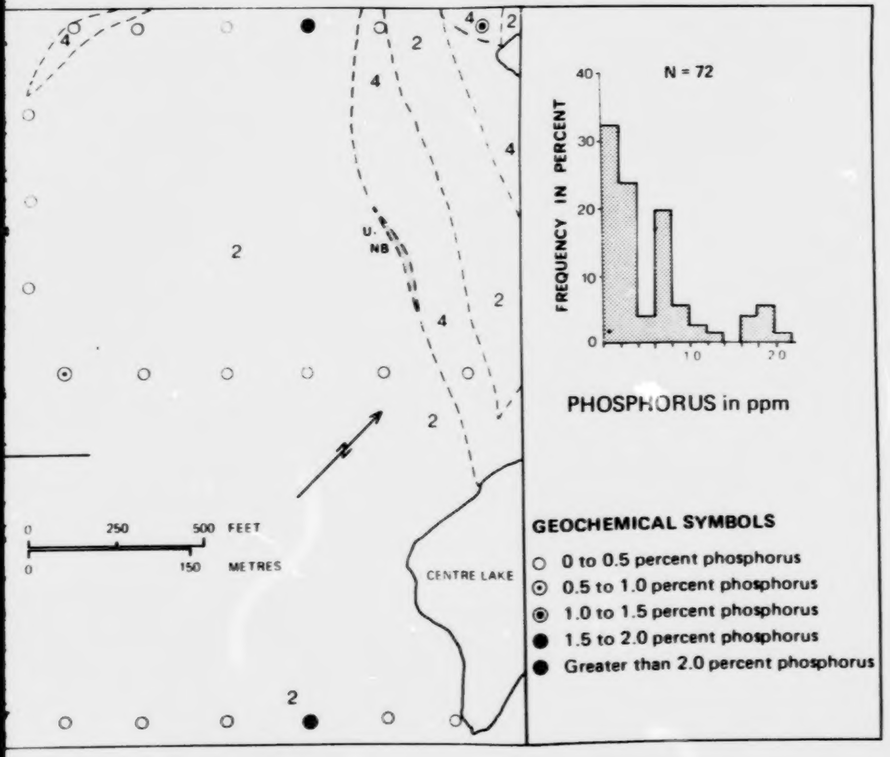

ANOMALY LAKE
CENTRE LAKE
RA
NB
U.
N = 72
FREQUENCY IN PERCENT
0
10
20
30
40
10
20
TITANIA in ppm
0
250
500 FEET
150 METRES
GEOCHEMICAL SYMBOLS
○ 0 to 3.0 percent titania
⊙ 3.0 to 6.0 percent titania
◉ 6.0 to 9.0 percent titania
● 9.0 to 12.0 percent titania
● Greater than 12.0 percent titania

Figure 39 – Geochemical map of titania in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.


N = 72
FREQUENCY IN PERCENT
0
10
20
30
40
1.0
2.0
PHOSPHORUS in ppm
0
250
500 FEET
150 METRES
U.
NB
CENTRE LAKE
GEOCHEMICAL SYMBOLS
○ 0 to 0.5 percent phosphorus
⊙ 0.5 to 1.0 percent phosphorus
◉ 1.0 to 1.5 percent phosphorus
● 1.5 to 2.0 percent phosphorus
● Greater than 2.0 percent phosphorus

samples, Prairie Lake detailed area.

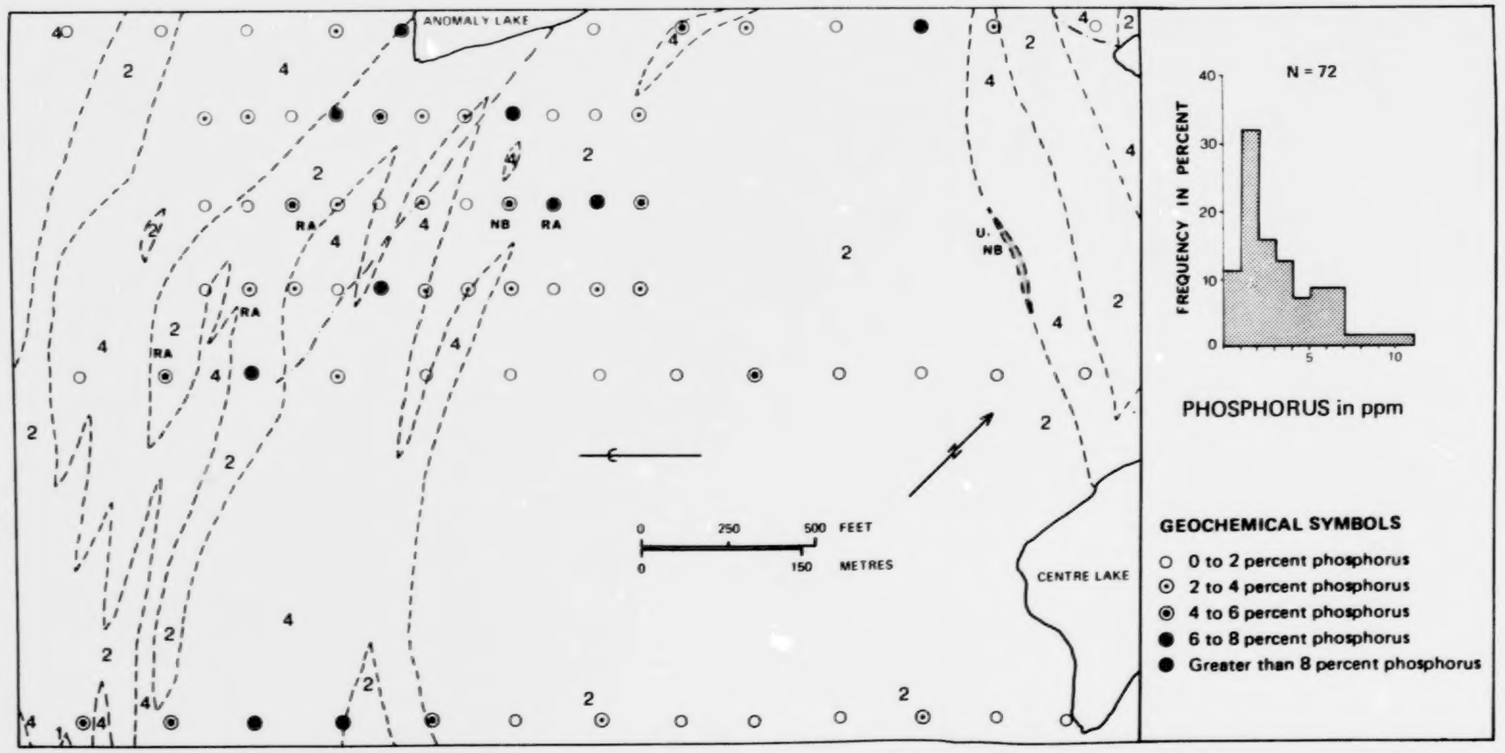

ANOMALY LAKE
CENTRE LAKE
RA
NB
U.
N = 72
FREQUENCY IN PERCENT
0
10
20
30
40
5
10
PHOSPHORUS in ppm
0
250
500 FEET
150 METRES
GEOCHEMICAL SYMBOLS
○ 0 to 2 percent phosphorus
⊙ 2 to 4 percent phosphorus
◉ 4 to 6 percent phosphorus
● 6 to 8 percent phosphorus
● Greater than 8 percent phosphorus

Figure 42 – Geochemical map of phosphorus in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.

LEGEND

5	Dike Rocks
4	Carbonatitic Rocks
3	Syenitic Rocks
2	Ijolitic Rocks
1	Granitic and Fenitized Rocks
- - -	Geological Contact
— —	Fault, inferred
⌀	Glacial Transport Direction
RA	Radioactivity
U	Uranium Occurrence
Nb	Nobium Occurrence

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

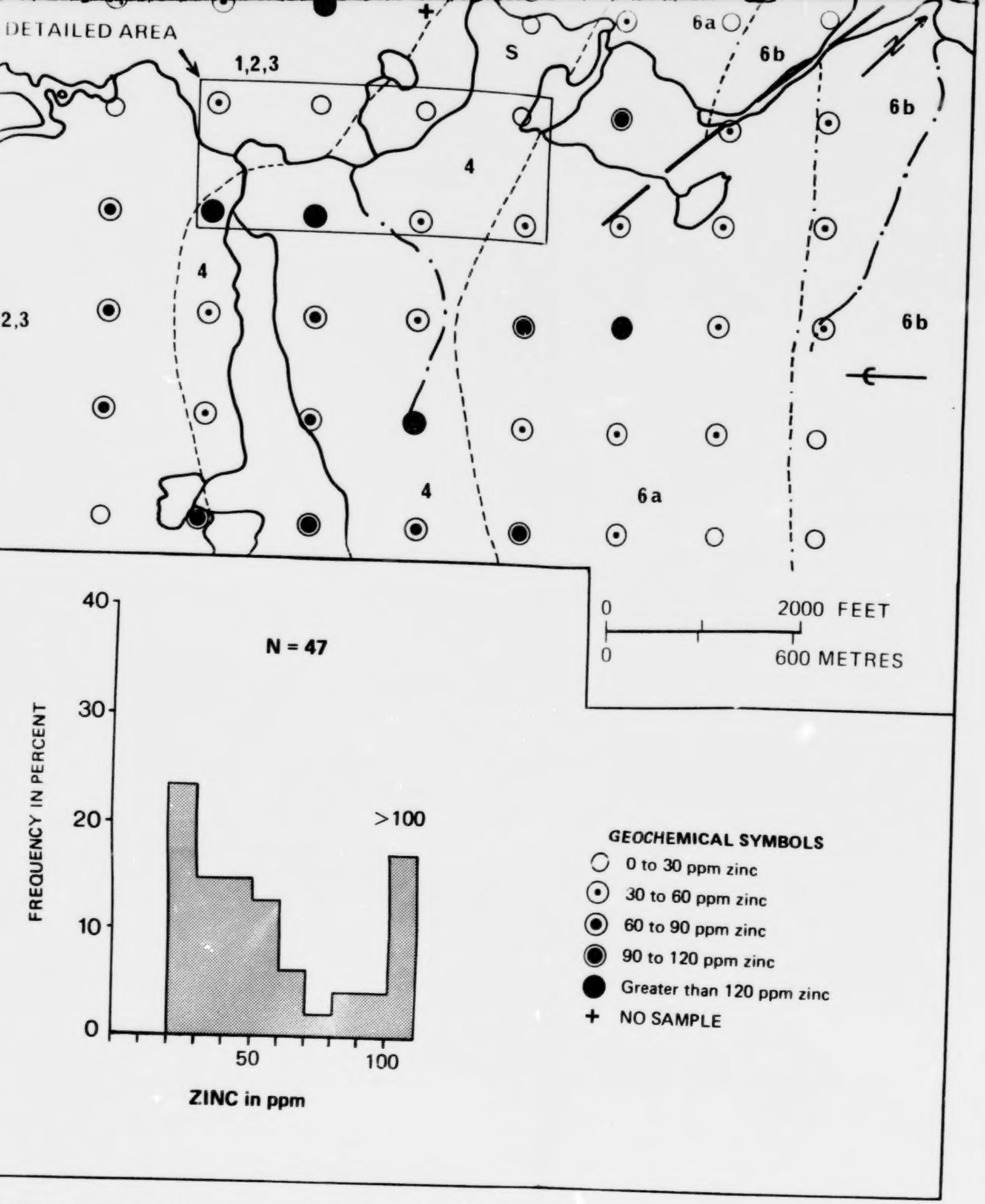
Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from unpublished geological map prepared for Newmont Mining Corporation of Canada Limited.

Magnetic declination approximately 3^{o} W, 1980.



e 55 – Geochemical map of zinc in 'B' horizon soils, Killala Lake area.

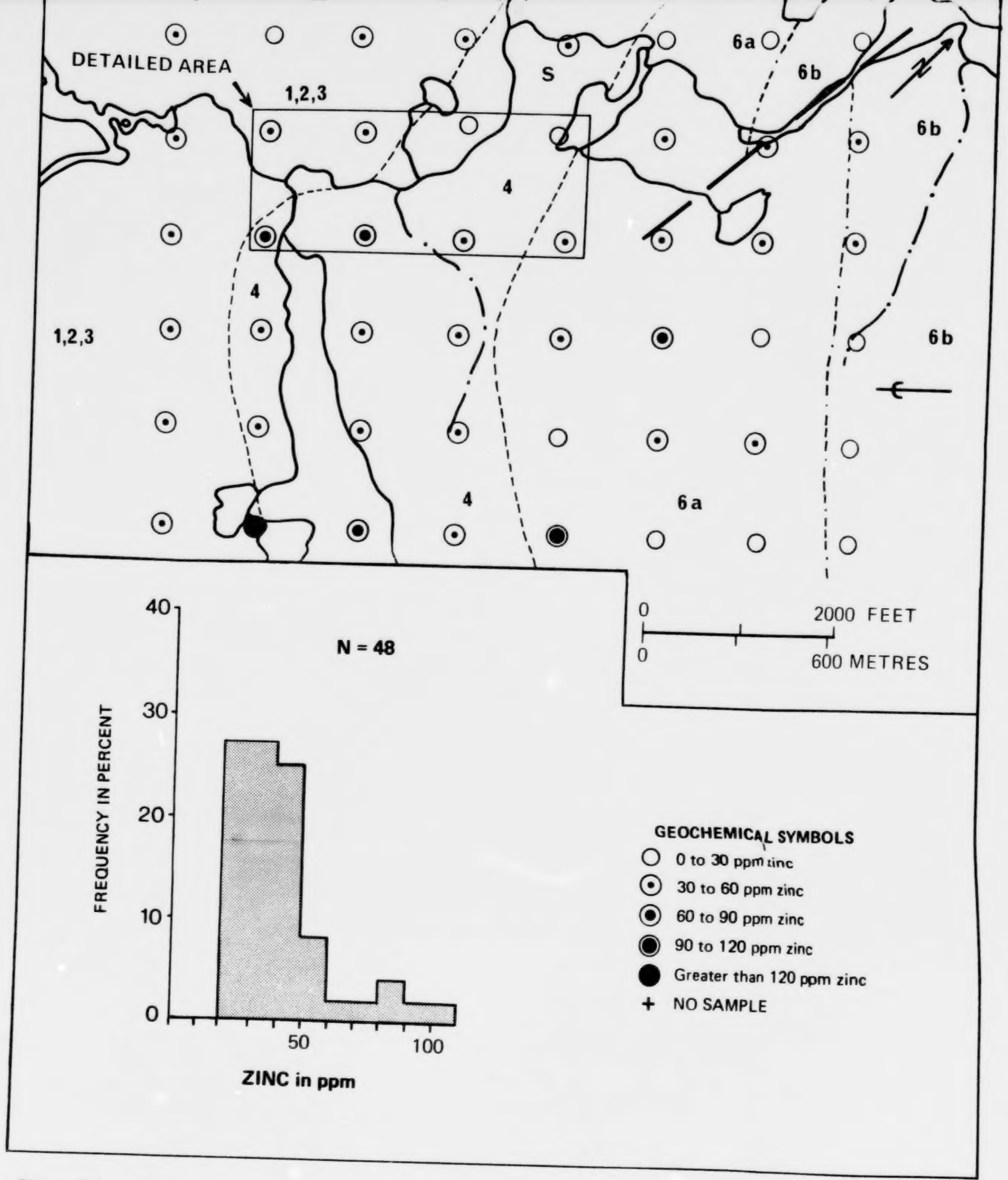


Figure 56 – Geochemical map of zinc in -250 mesh till samples, Killala Lake area.

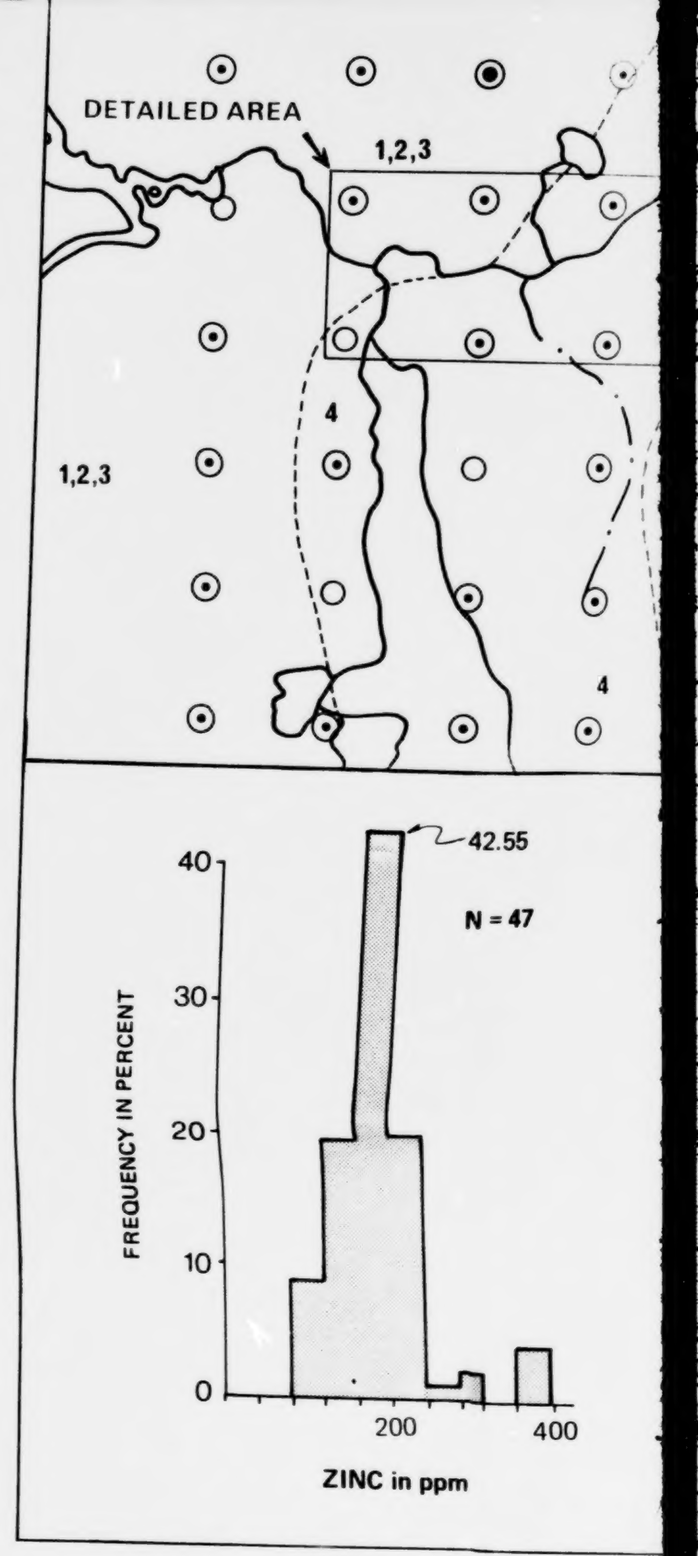
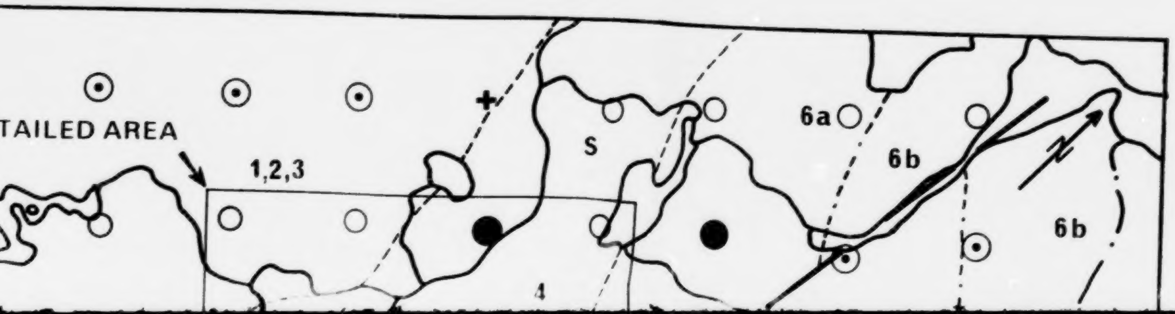
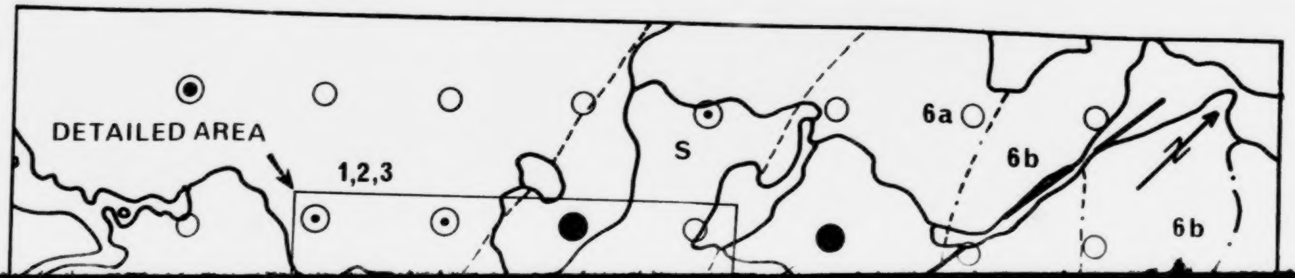
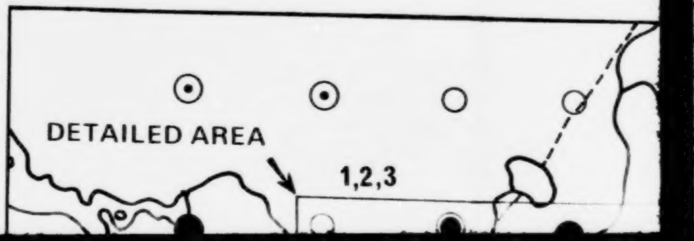
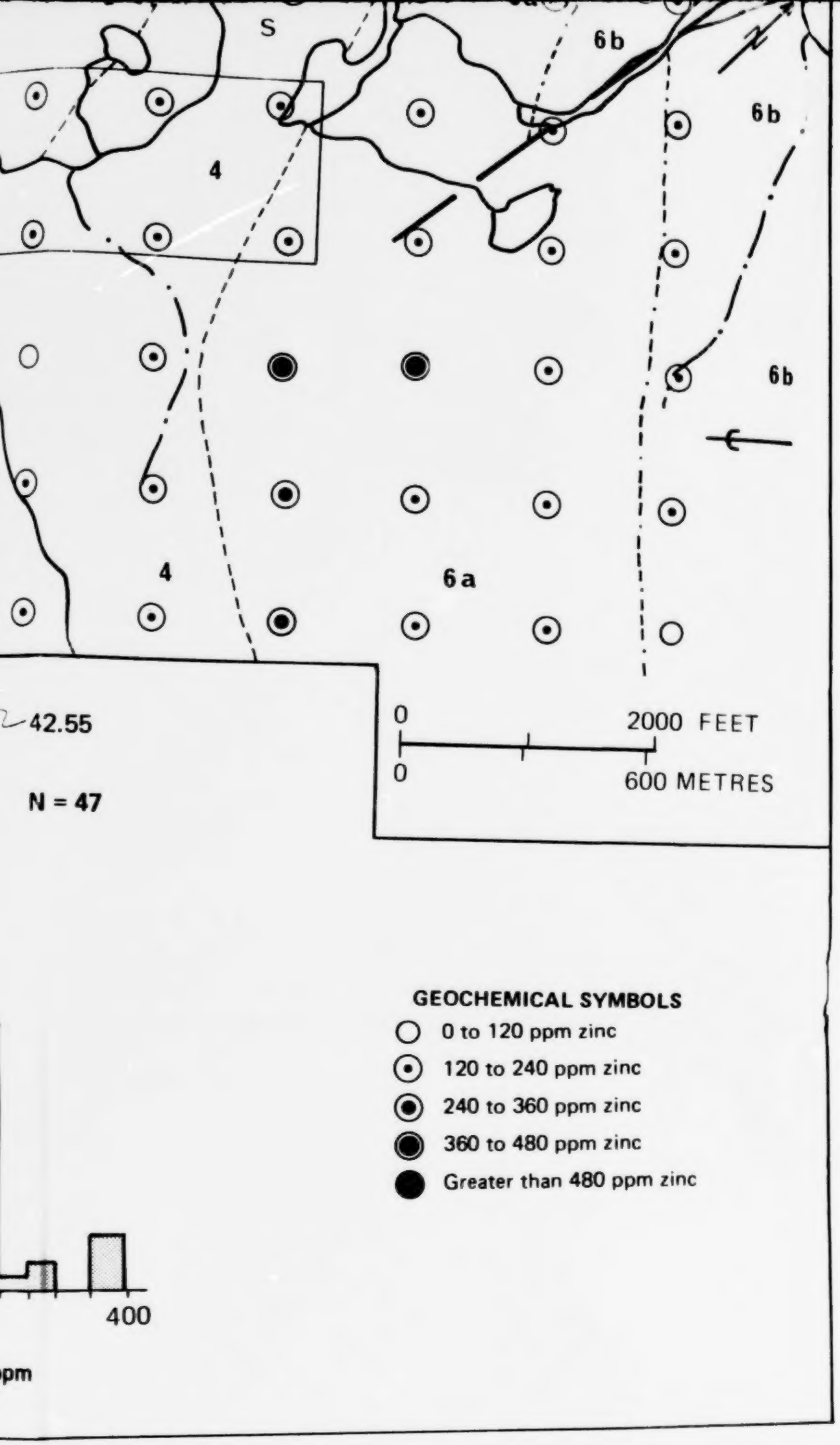


Figure 57 – Geochemical map of zinc in heavy mineral
area.









zinc in heavy mineral separates of -60 +250 mesh till samples, Killala Lake

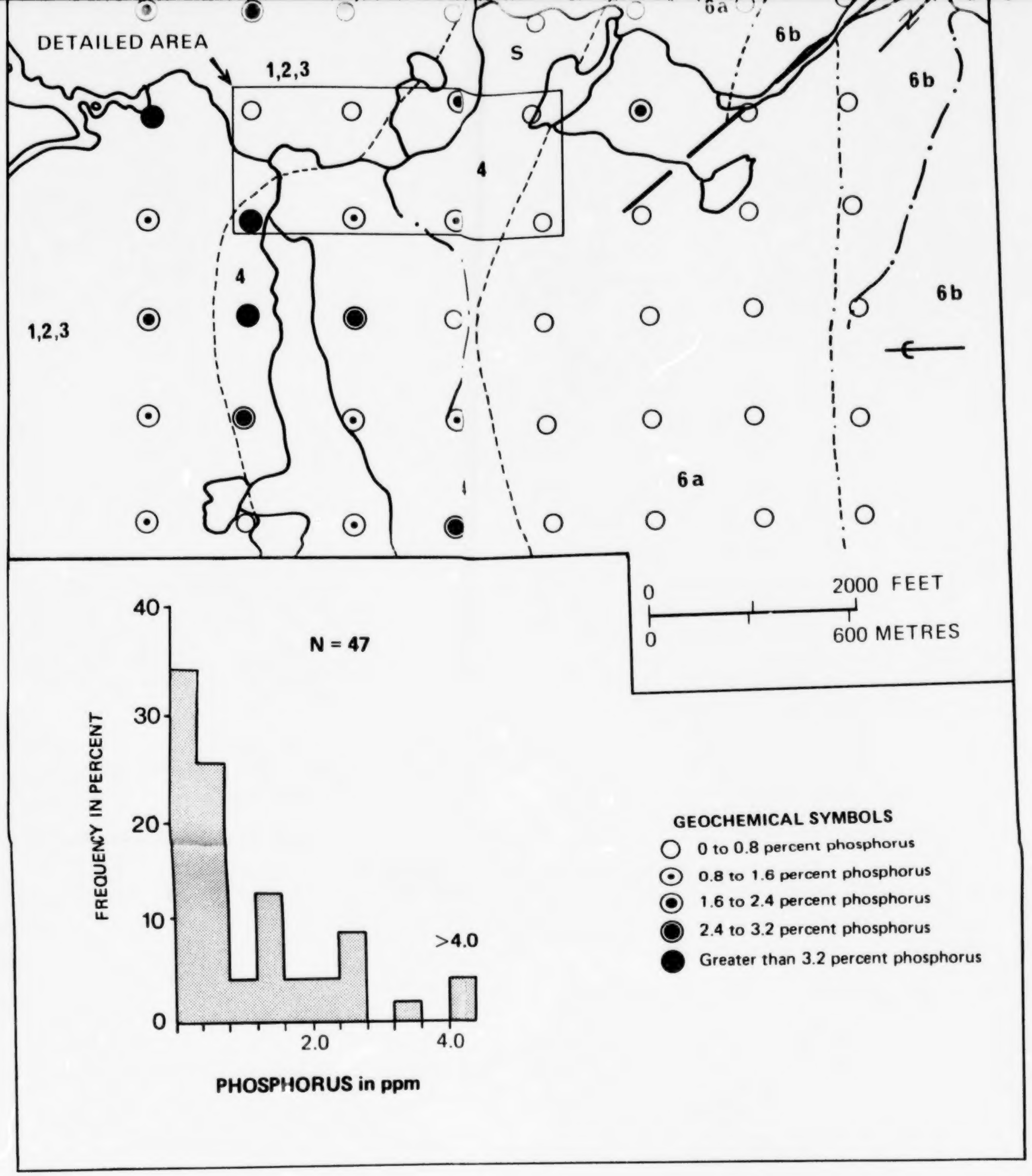

DETAILED AREA
1,2,3
S
6a
6b
4
1,2,3
0
2000 FEET
600 METRES
N = 47
40
30
20
10
0
FREQUENCY IN PERCENT
>4.0
2.0
4.0
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.8 percent phosphorus
⊙ 0.8 to 1.6 percent phosphorus
◉ 1.6 to 2.4 percent phosphorus
◉ 2.4 to 3.2 percent phosphorus
● Greater than 3.2 percent phosphorus

Figure 61 – Geochemical map of phosphorus in heavy mineral separates of -60 +250 mesh till samples, Killala Lake area.

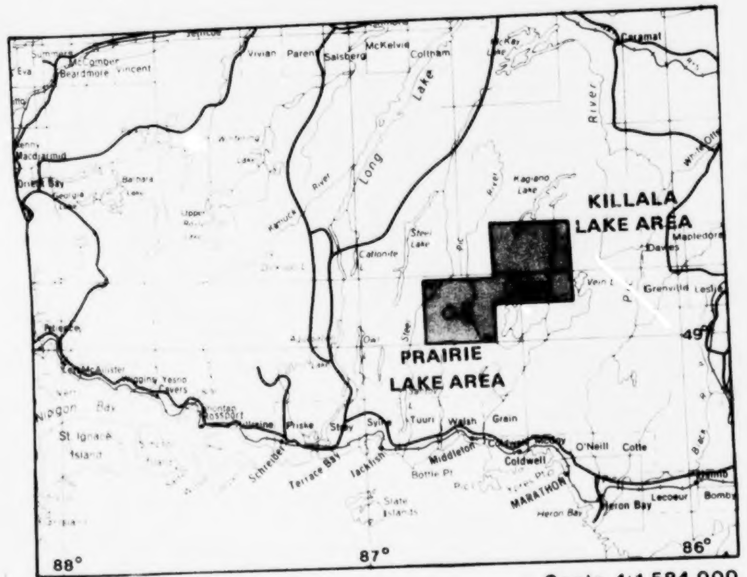
Investigations of
and Killala Lake.
Chart C-1
Figures 55 to 62 (inclusive)

CHART C–1

Geochemical Distribution of ZINC, COPPER, AND PHOSPHORUS IN OVERBURDEN

KILLALA LAKE AREA

District of Thunder Bay



LOCATION MAP

Scale 1:1 584 000

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

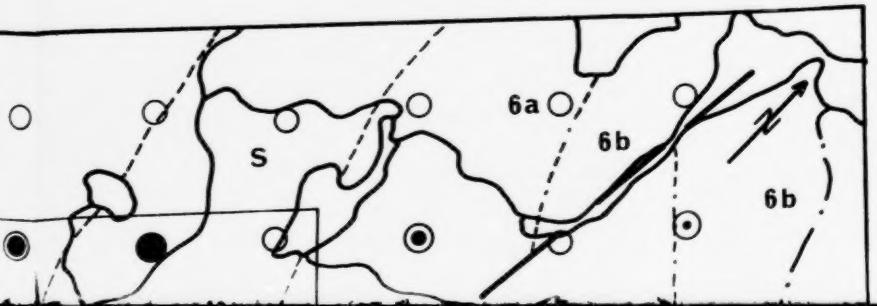
Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

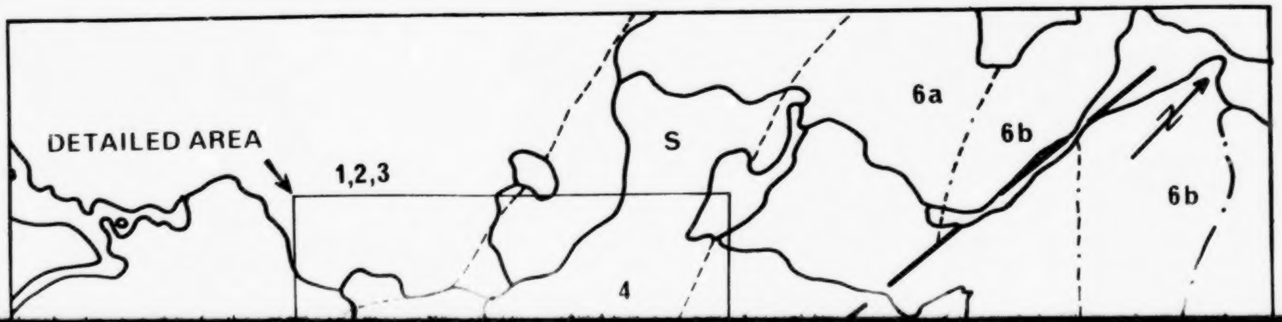
Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

Magnetic declination approximately 3° W, 1980.





ure 55 – Geochemical map of zinc in 'B' horizon soils, Killala Lake area.

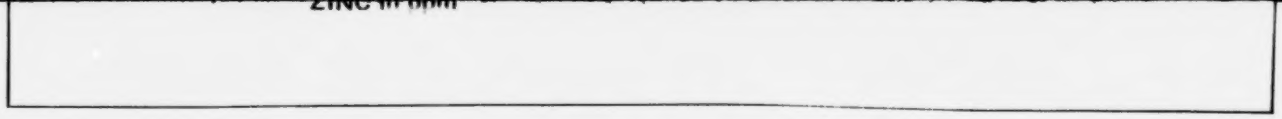


Figure 56 – Geochemical map of zinc in -250 mesh till samples, Killala Lake area.

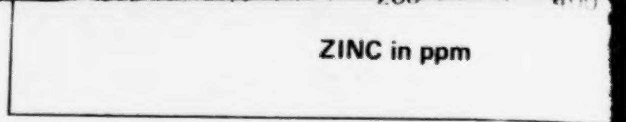
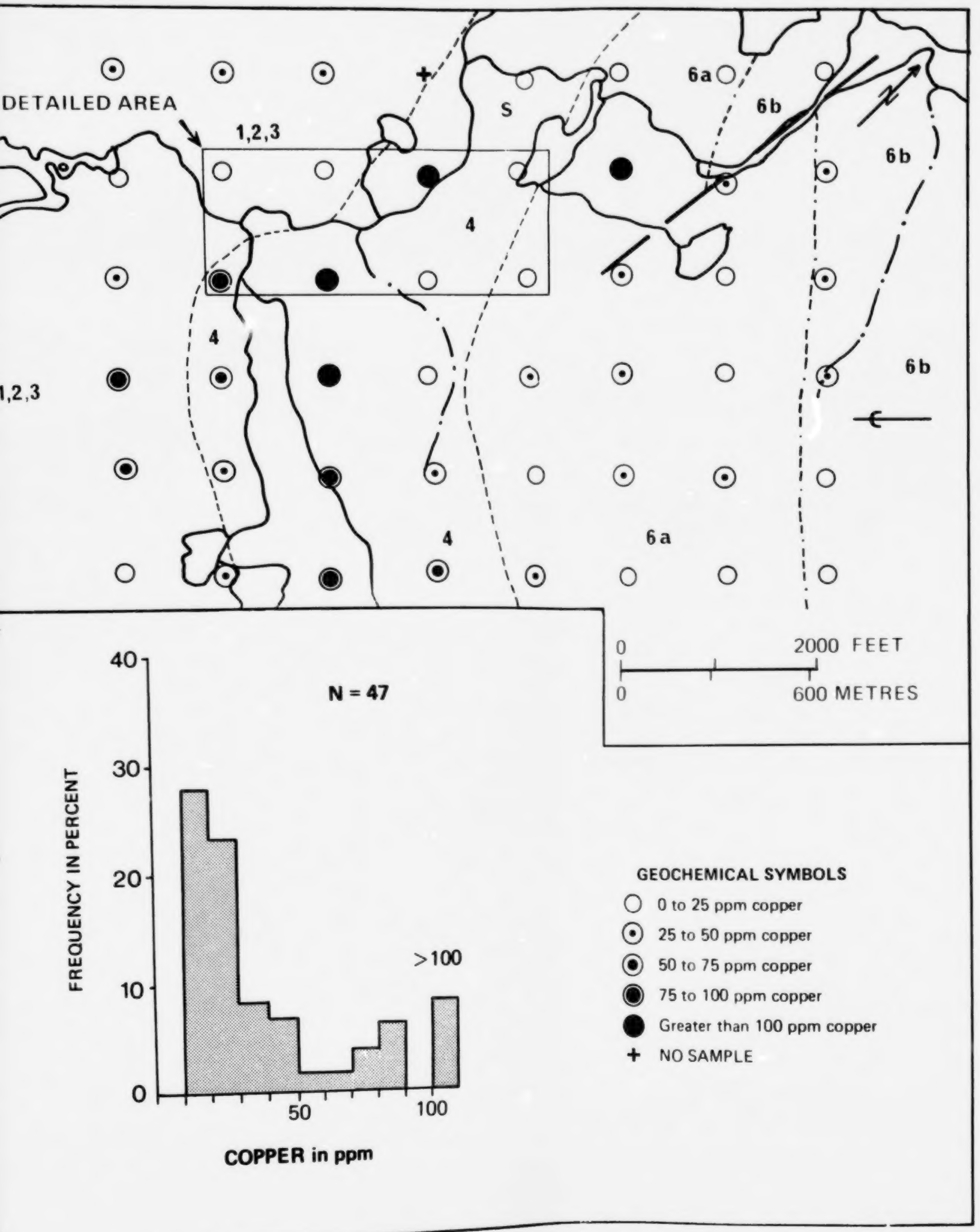


Figure 57 – Geochemical map of zinc in heavy mi
area.



igure 58 – Geochemical map of copper in 'B' horizon soils, Killala Lake area.

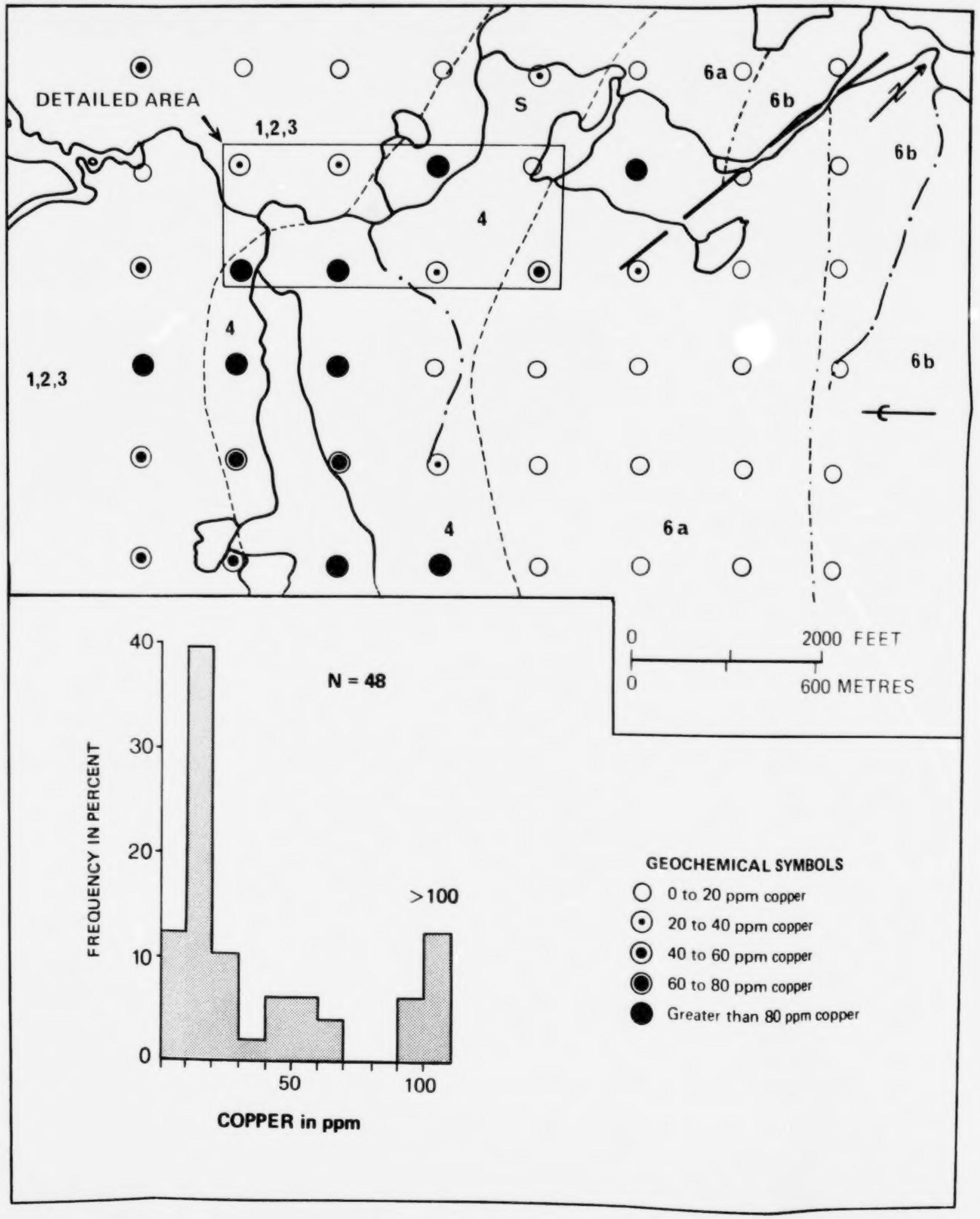


Figure 59 – Geochemical map of copper in -250 mesh till samples, Killala Lake area.

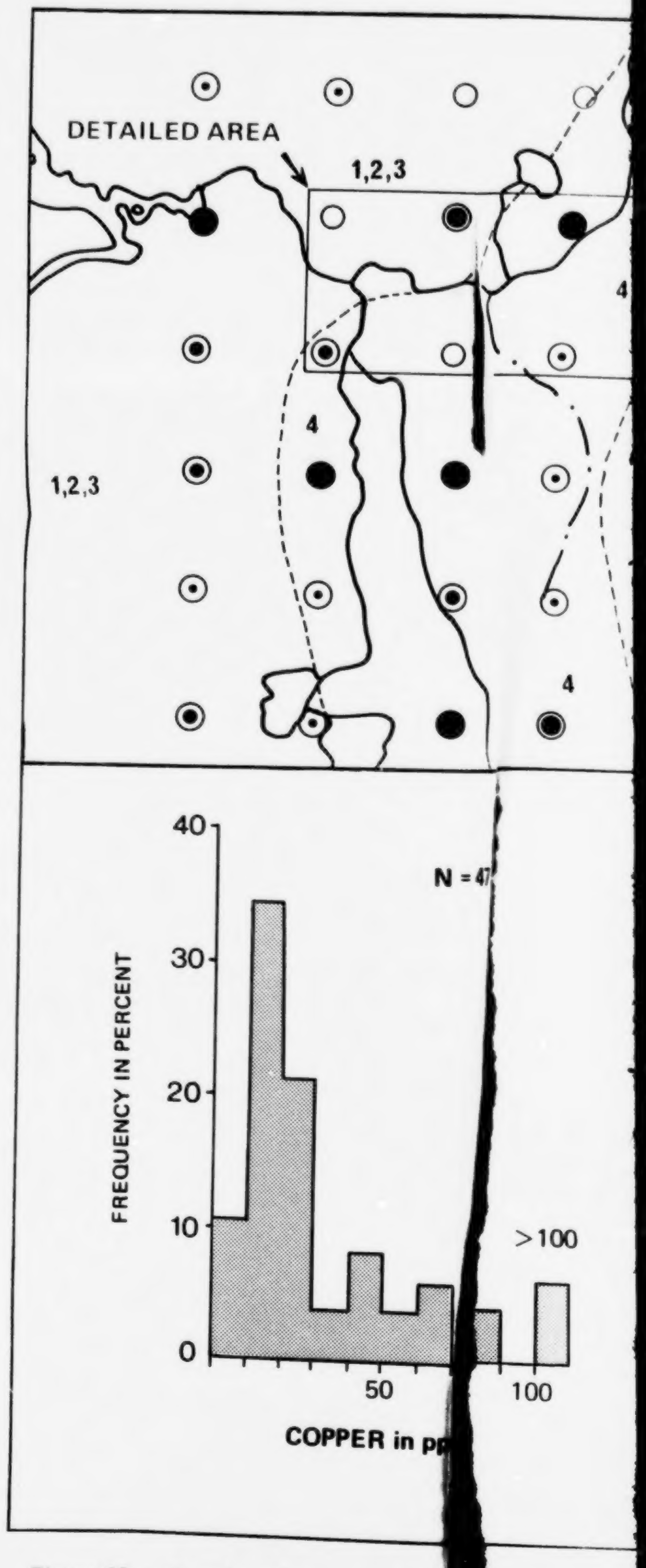
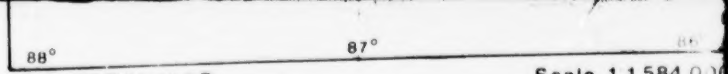


Figure 60 – Geochemical map of cop heavy mine
Lake area.

map of zinc in heavy mineral separates of -60 +250 mesh till samples, Killala Lake

Figure 61 – Geochemical map of phosphorus in heavy mineral separates of -60 +250 mesh till samples, Killala Lake area.



LOCATION MAP

Scale 1 1 584 0

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

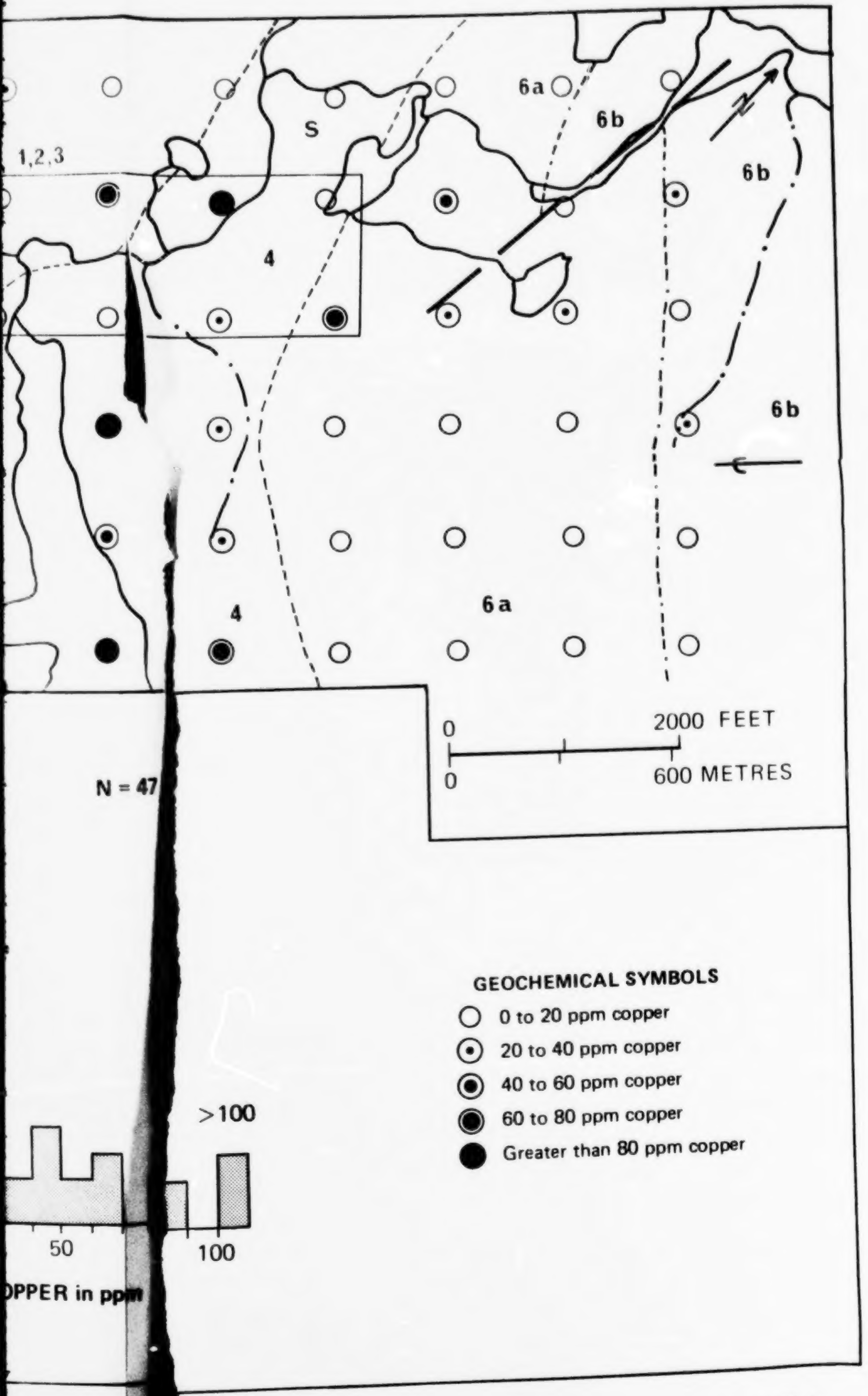
Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

Magnetic declination approximately 3° W, 1980.



map of cop n heavy mineral separates of -60 +250 mesh till samples, Killala

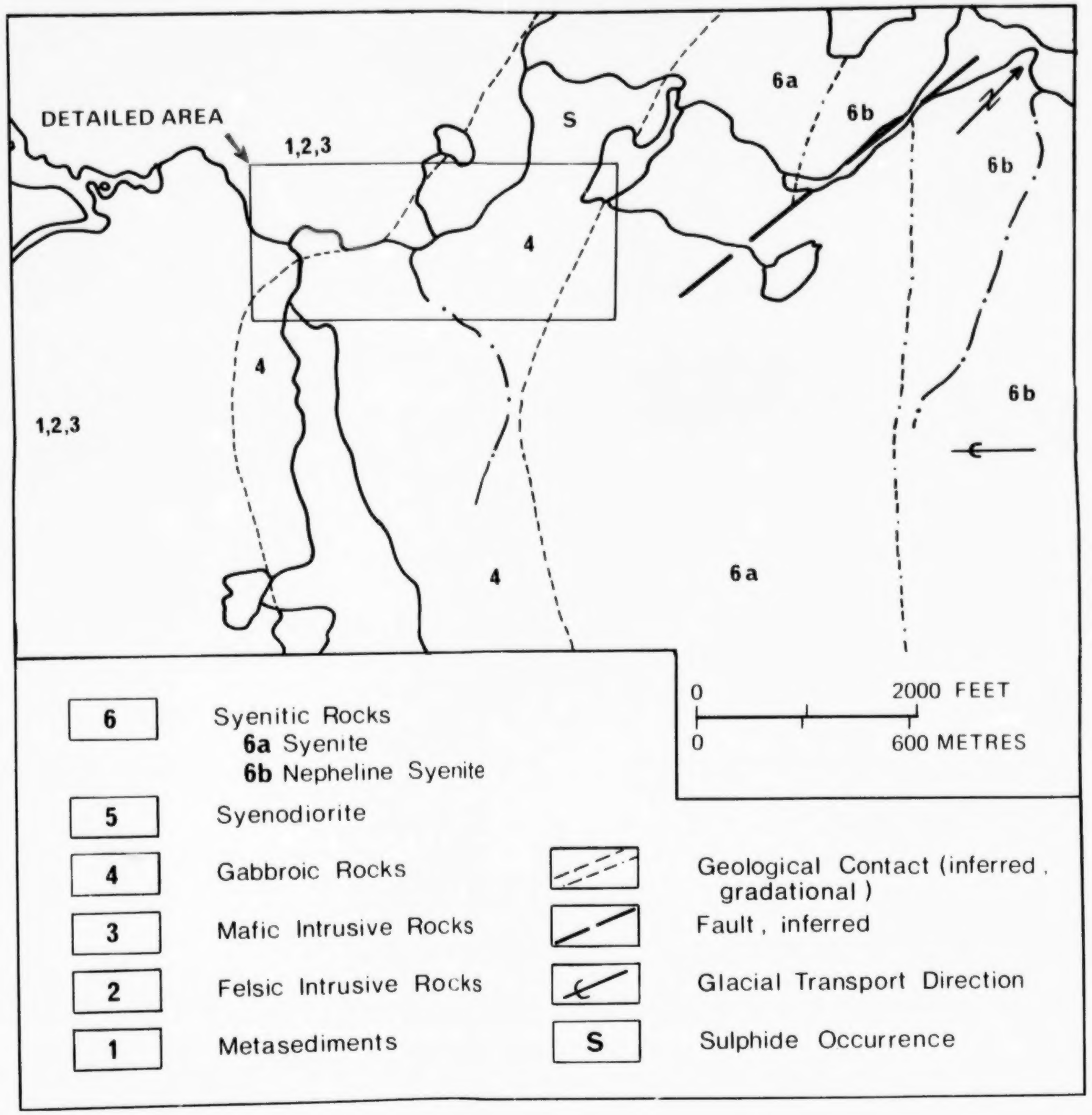


Figure 62 – Bedrock geology, Killala Lake area.

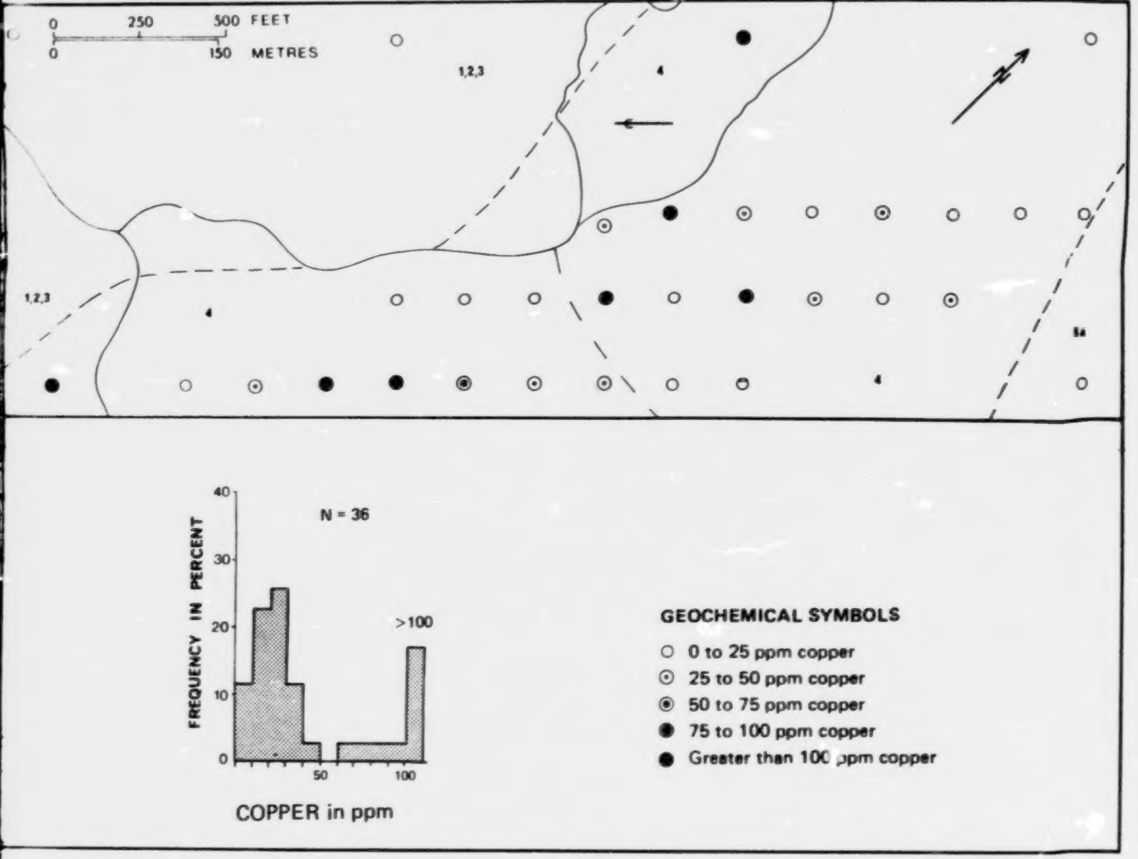


Figure 69 – Geochemical map of copper in 'B' horizon soils, Killala Lake detailed area.

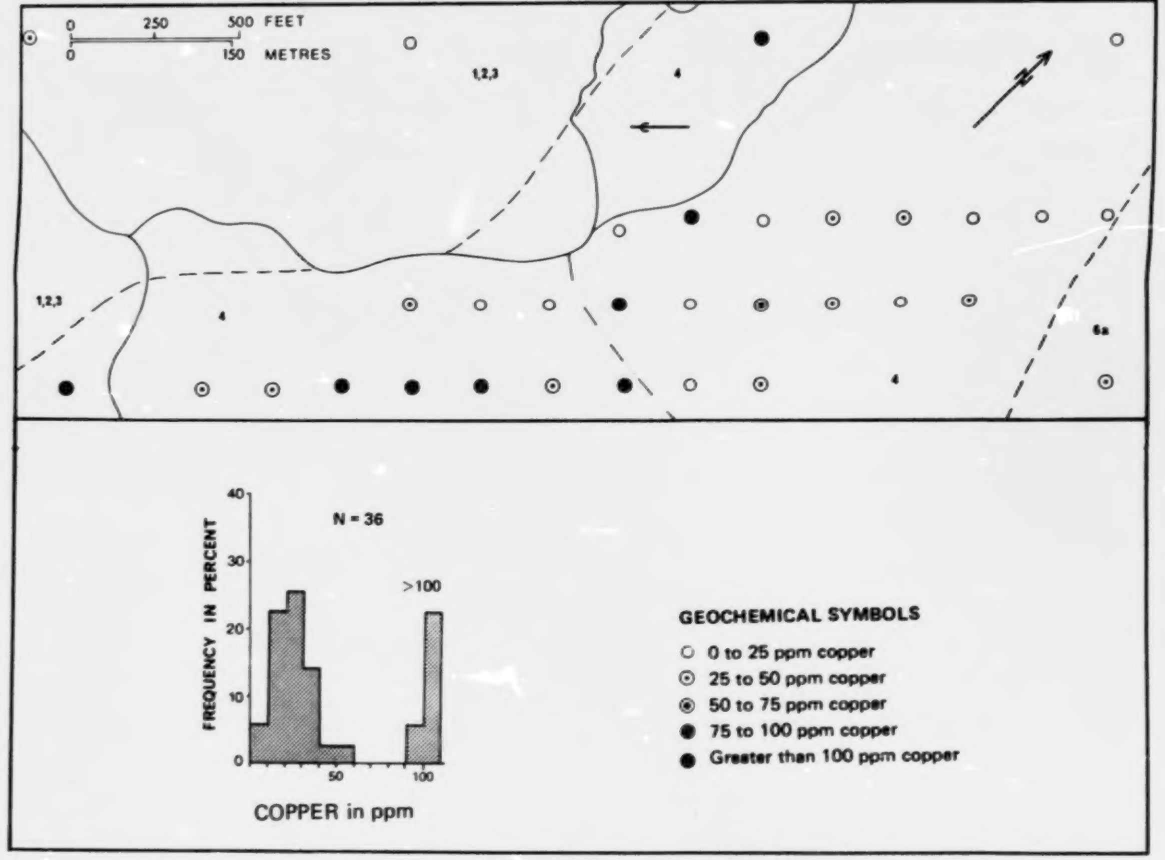


Figure 70 – Geochemical map of copper in -250 mesh till samples, Killala Lake detailed area.

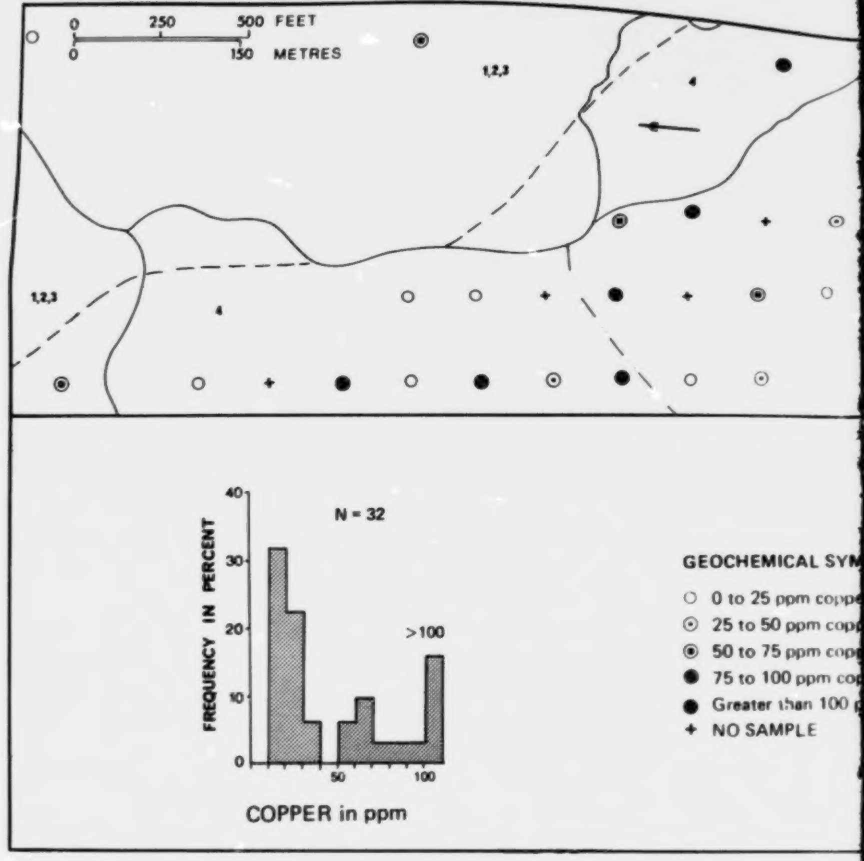


Figure 71 – Geochemical map of copper in heavy mineral separates of -60 +250
samples, Killala Lake detailed area.

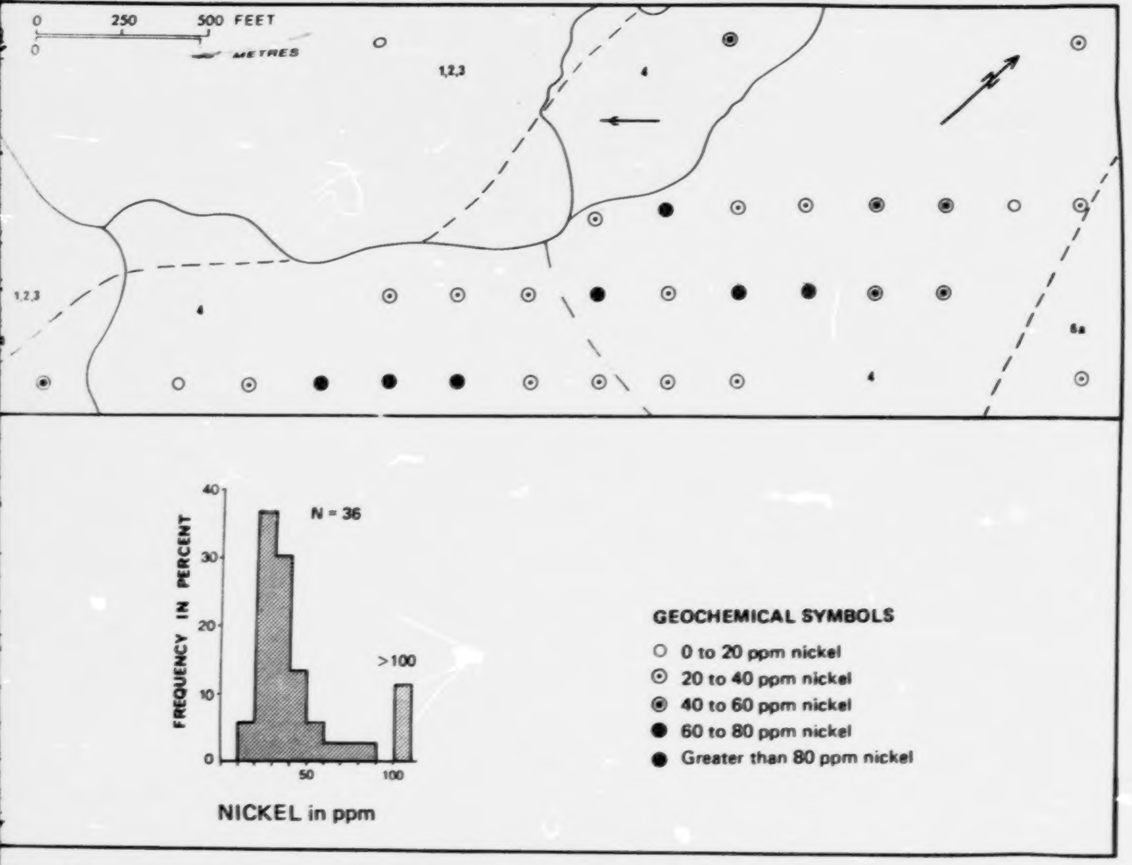


Figure 72 – Geochemical map of nickel in 'B' horizon soils, Killala Lake detailed area.

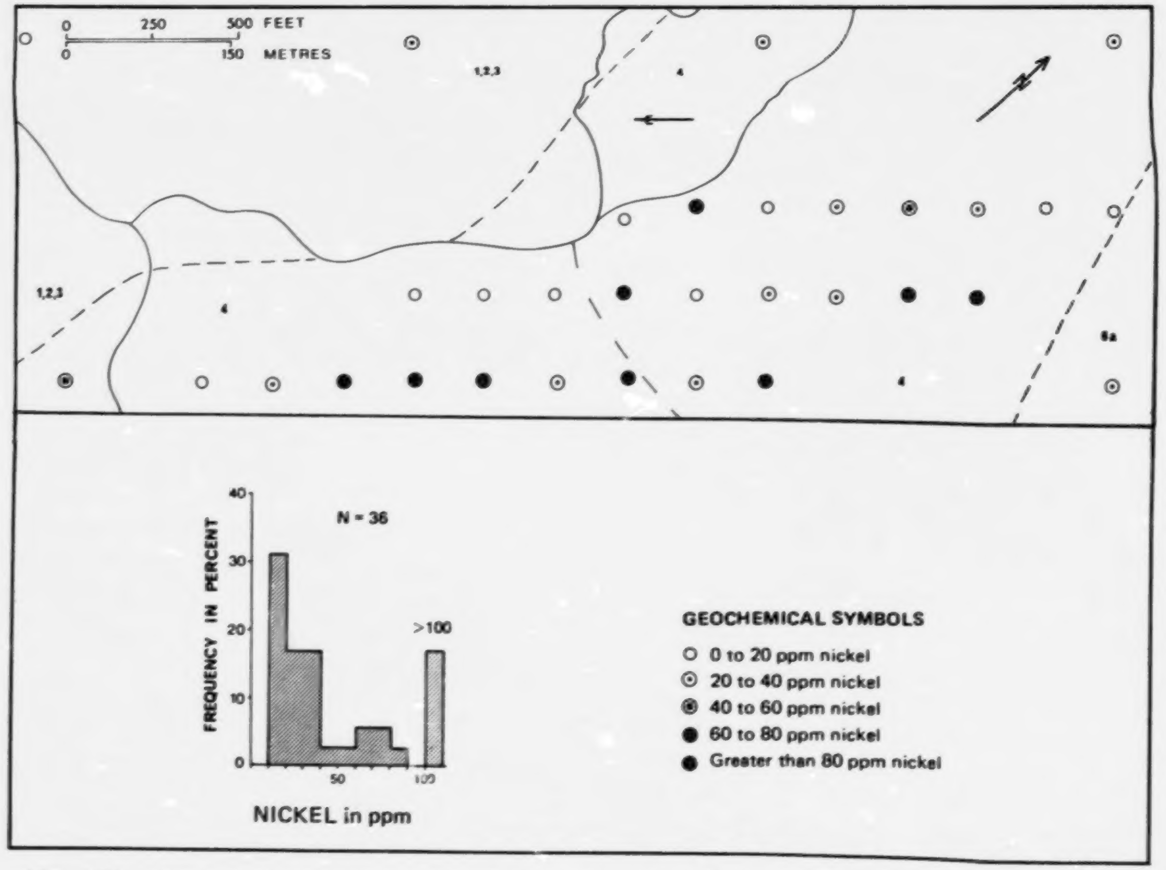


Figure 73 – Geochemical map of nickel in -250 mesh till samples, Killala Lake detailed area.

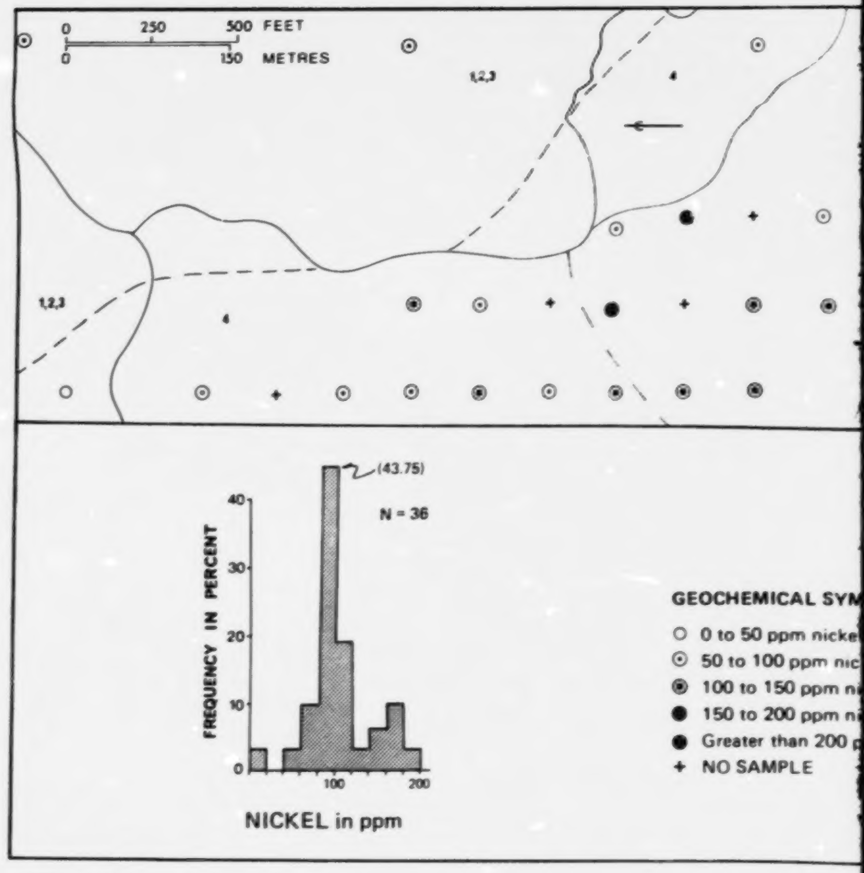


Figure 74 – Geochemical map of nickel in heavy mineral separates of -60 +250

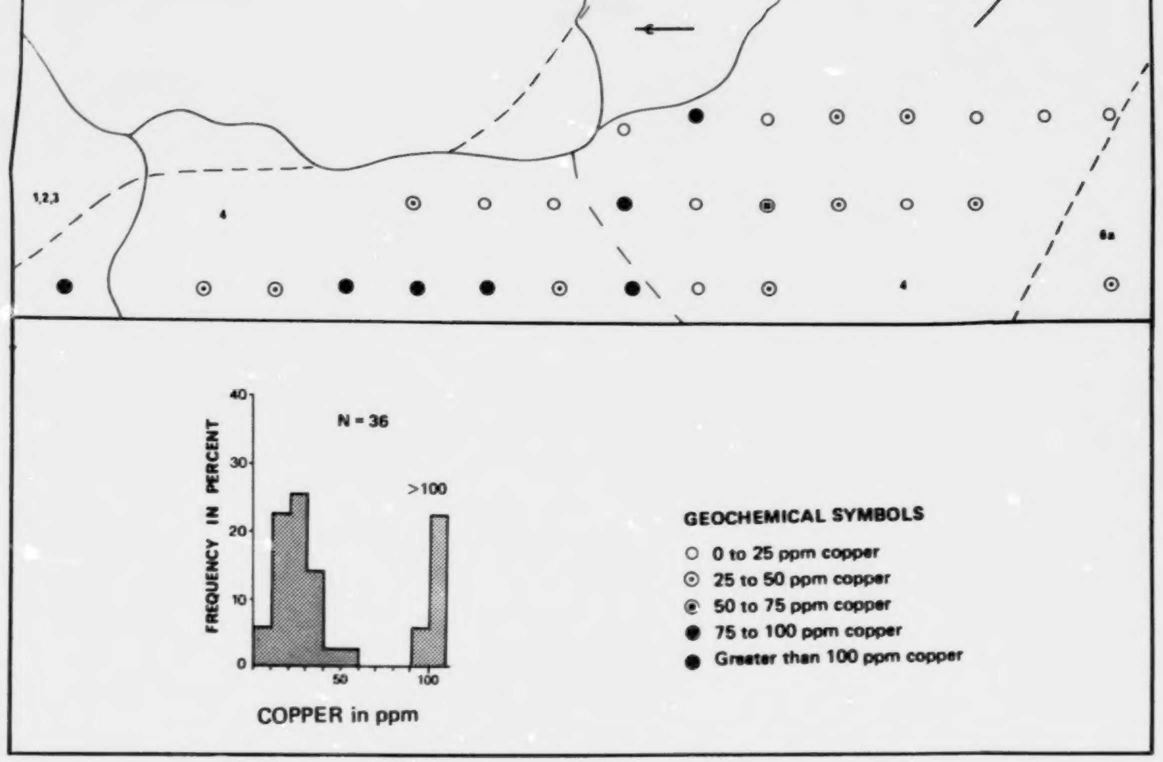


Figure 70 – Geochemical map of copper in -250 mesh till samples, Killala Lake detailed area.

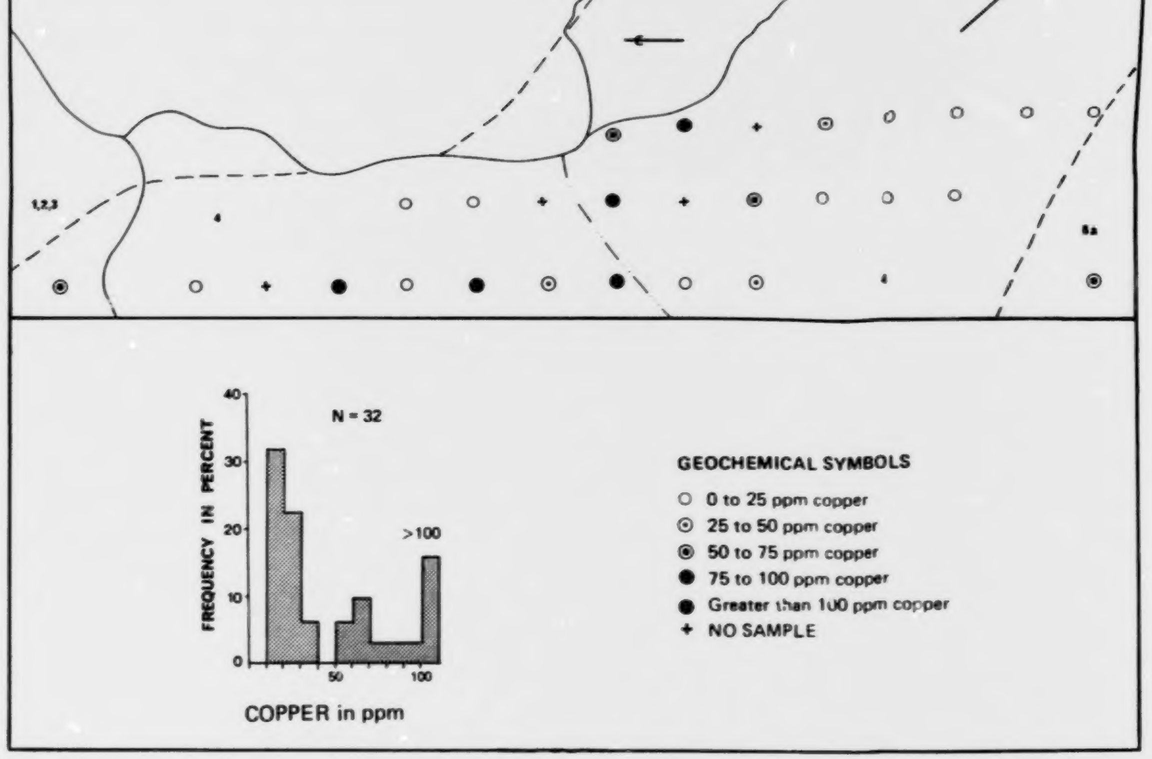


Figure 71 – Geochemical map of copper in heavy mineral separates of -60 +250 mesh till samples, Killala Lake detailed area.

CHART D

Geochemical Distribution of COPPER, NICKEL, TITANIUM/TITANIA, AND PHOSPHORUS IN OVERBURDEN

KILLALA LAKE DETAILED AREA

District of Thunder Bay

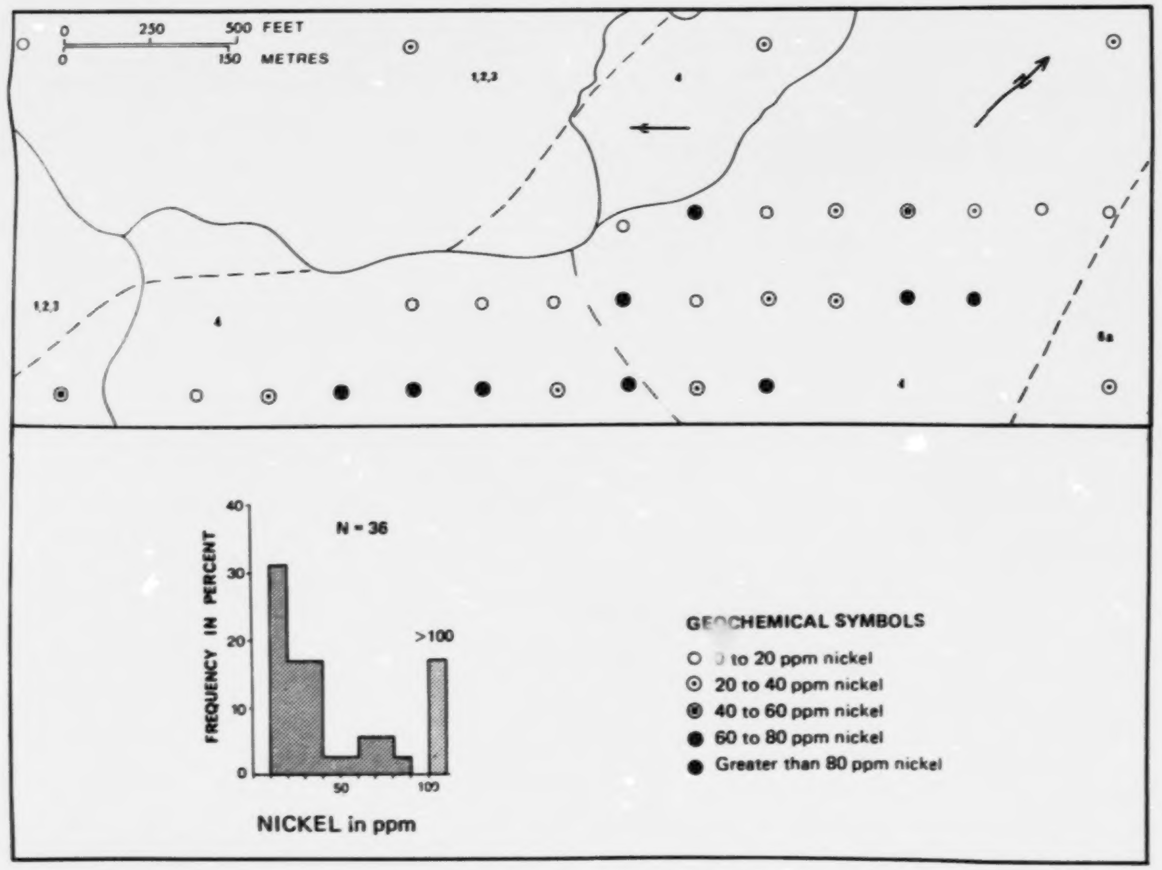


Figure 73 – Geochemical map of nickel in -250 mesh till samples, Killala Lake detailed area.

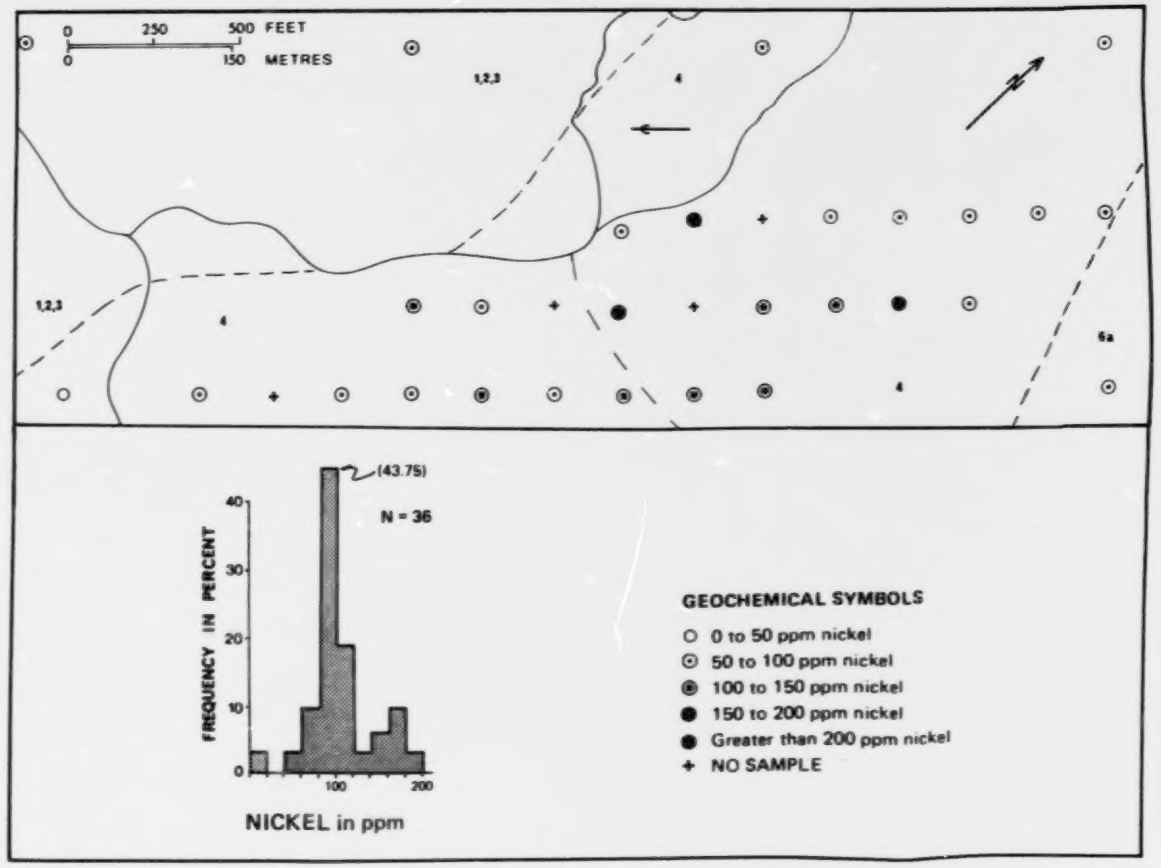
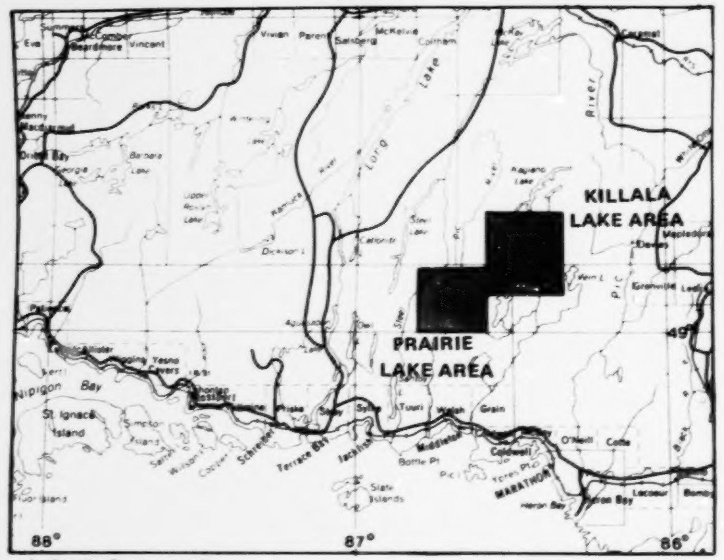


Figure 74 – Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Killala Lake detailed area.



LOCATION MAP

Scale 1:1 584 000

LEGEND

6	Syenitic Rocks 6a Syenite

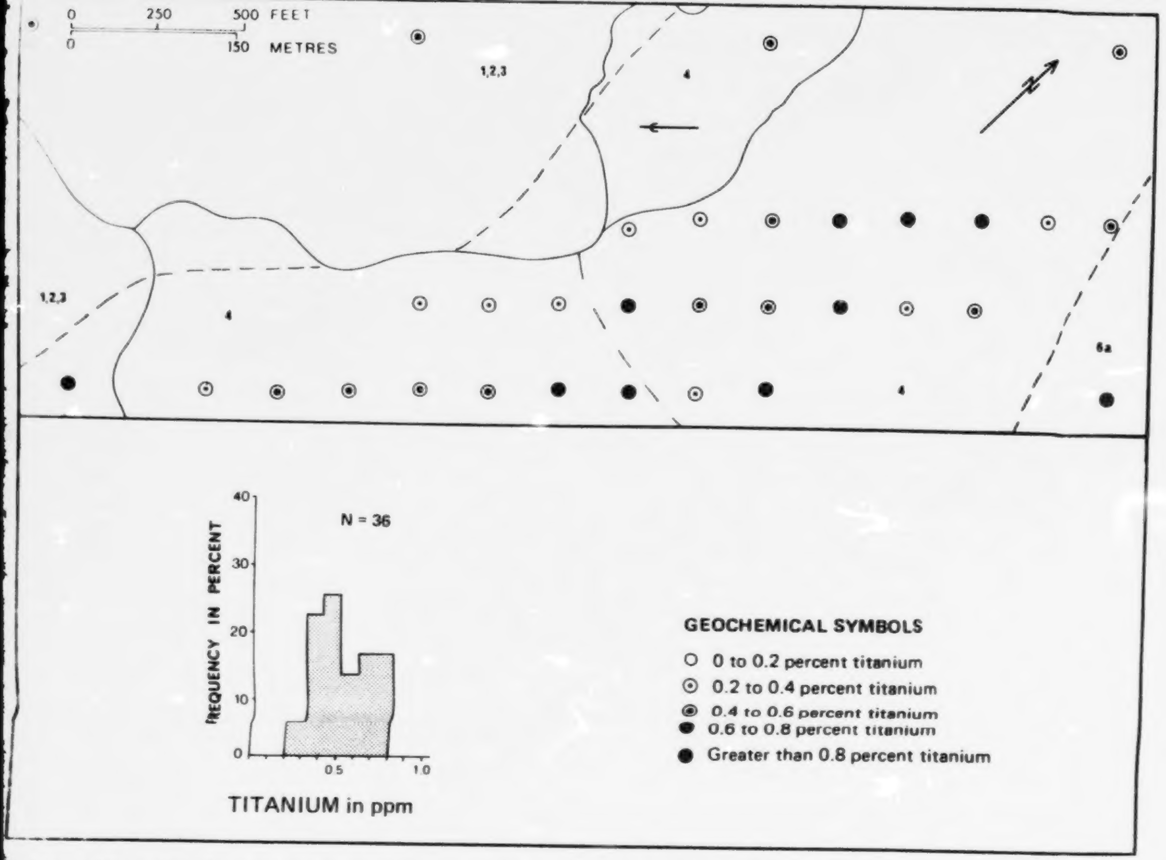

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
N = 36
FREQUENCY IN PERCENT
40
30
20
10
0
0.5
1.0
TITANIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.2 percent titanium
⊙ 0.2 to 0.4 percent titanium
◉ 0.4 to 0.6 percent titanium
● 0.6 to 0.8 percent titanium
● Greater than 0.8 percent titanium

Figure 75 – Geochemical map of titanium in 'B' horizon soils, Killala Lake detailed area.

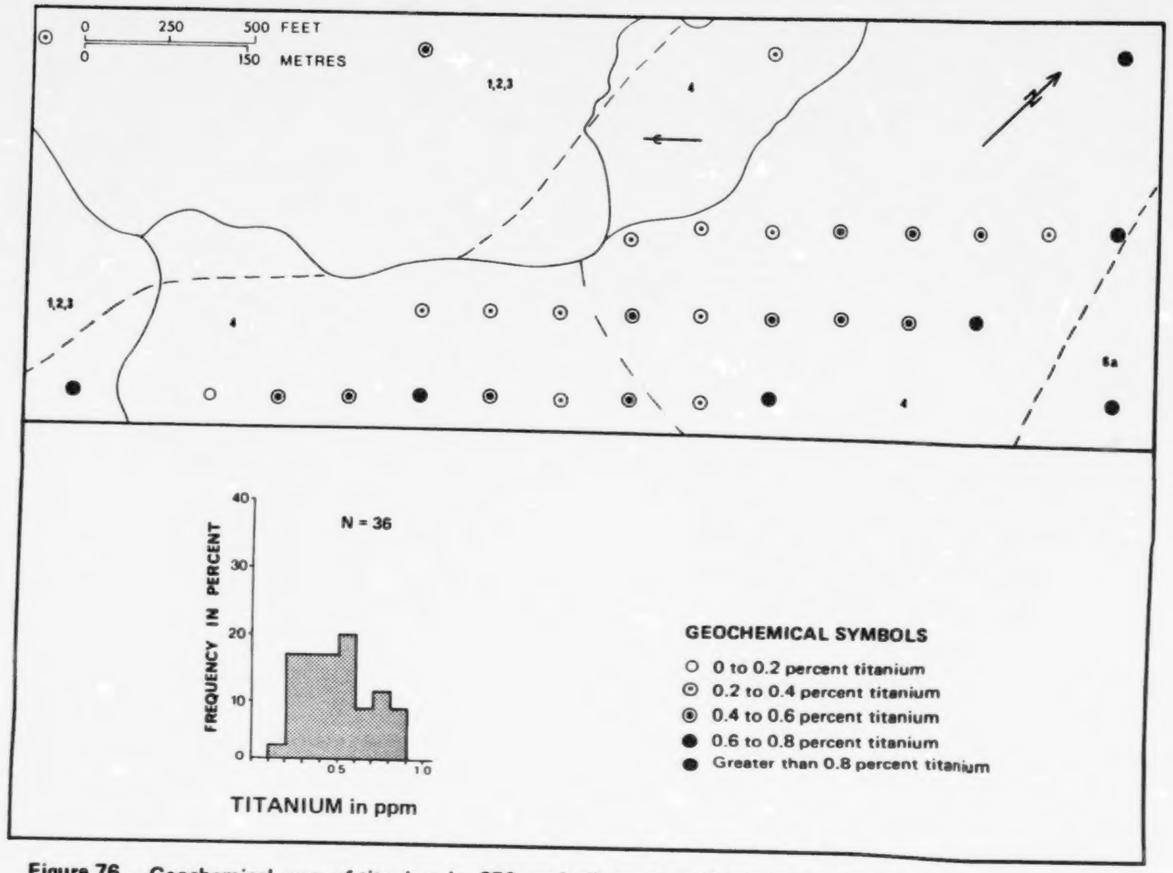

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
N = 36
FREQUENCY IN PERCENT
40
30
20
10
0
0.5
1.0
TITANIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.2 percent titanium
⊙ 0.2 to 0.4 percent titanium
◉ 0.4 to 0.6 percent titanium
● 0.6 to 0.8 percent titanium
● Greater than 0.8 percent titanium

Figure 76 – Geochemical map of titanium in -250 mesh till samples, Killala Lake detailed area.

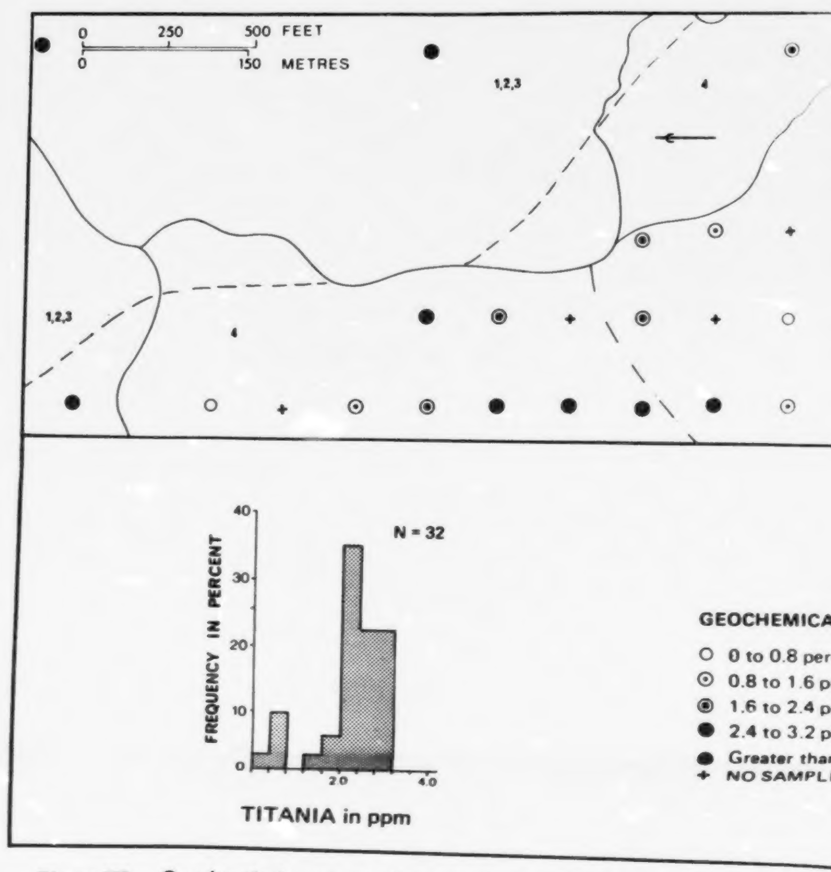


Figure 77 – Geochemical map of titania in heavy mineral separates of -60 +2
samples, Killala Lake detailed area.

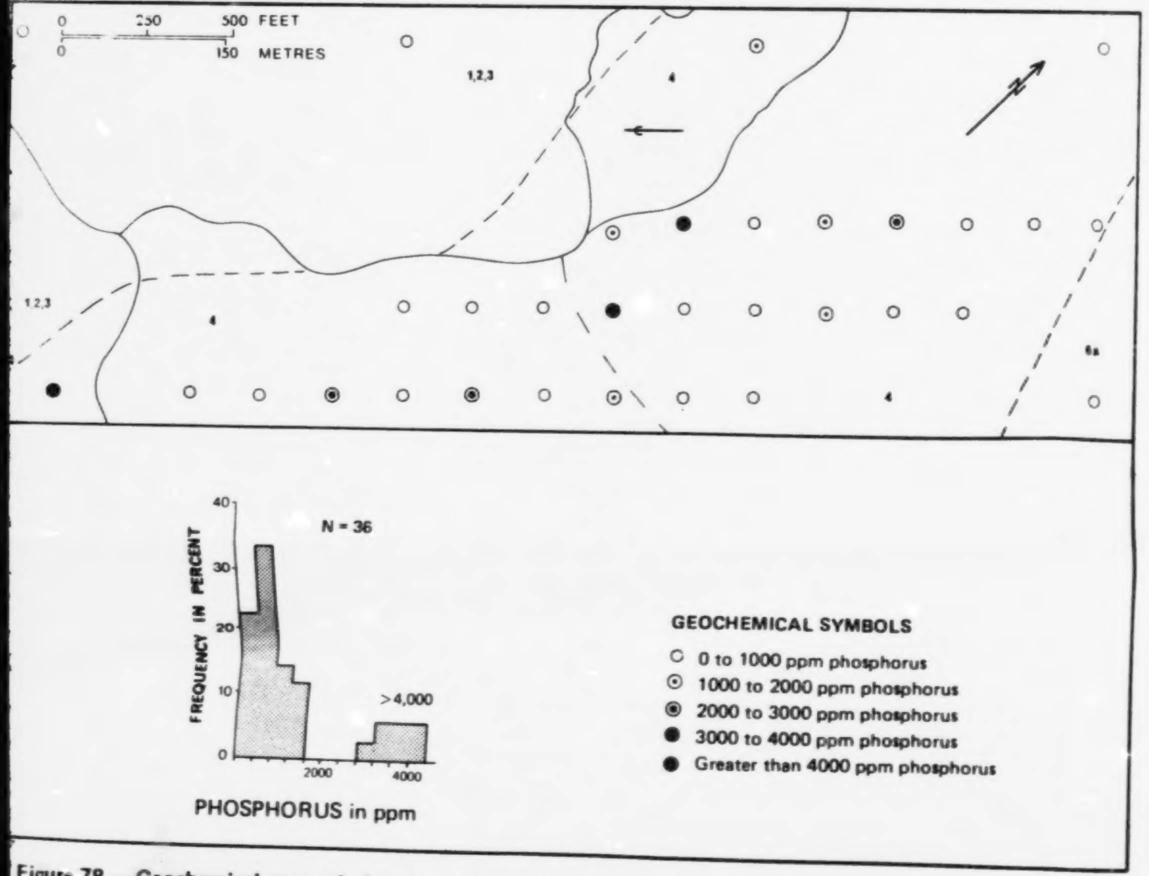

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
N = 36
FREQUENCY IN PERCENT
40
30
20
10
0
2000
4000
>4,000
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 1000 ppm phosphorus
⊙ 1000 to 2000 ppm phosphorus
◉ 2000 to 3000 ppm phosphorus
● 3000 to 4000 ppm phosphorus
● Greater than 4000 ppm phosphorus

Figure 78 – Geochemical map of phosphorus in 'B' horizon soils, Killala Lake detailed area.

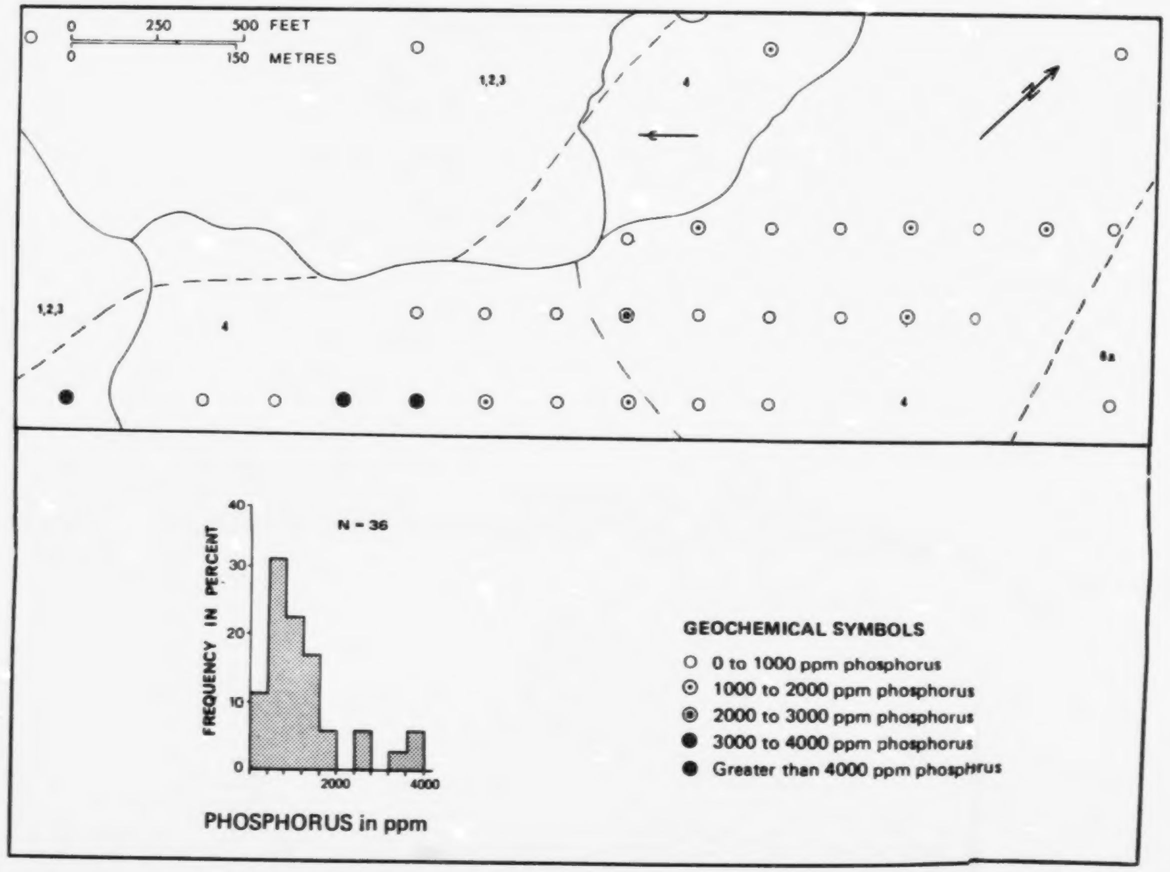

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
N = 36
FREQUENCY IN PERCENT
40
30
20
10
0
2000
4000
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 1000 ppm phosphorus
⊙ 1000 to 2000 ppm phosphorus
◉ 2000 to 3000 ppm phosphorus
● 3000 to 4000 ppm phosphorus
● Greater than 4000 ppm phosphrus

Figure 79 – Geochemical map of phosphorus in -250 mesh till samples, Killala Lake detailed
area.

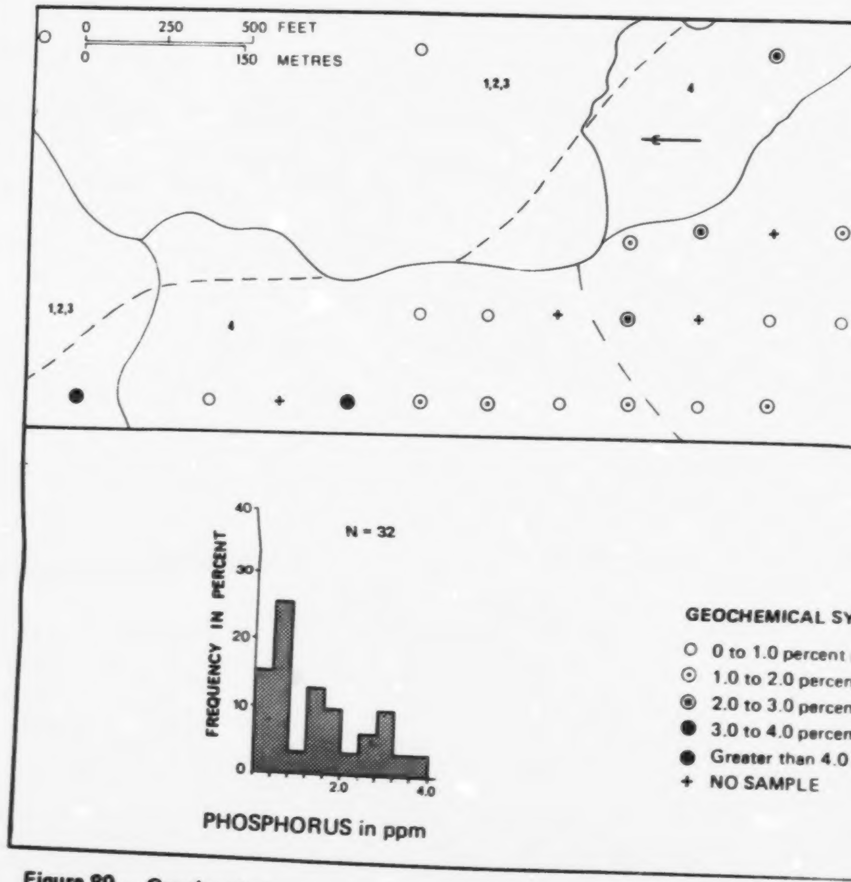


Figure 80 – Geochemical map of phosphorus in heavy mineral separates of

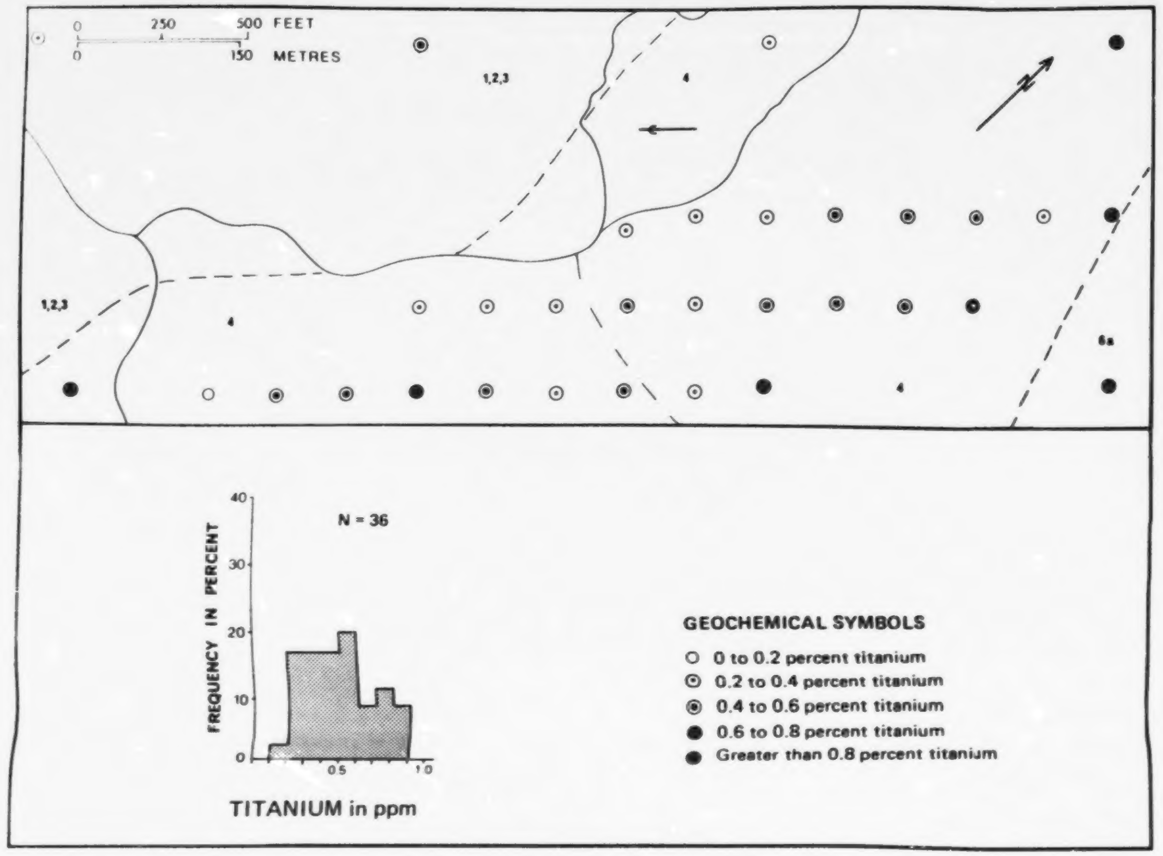

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
40
30
20
10
0
0.5
1.0
FREQUENCY IN PERCENT
N = 36
TITANIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.2 percent titanium
⊙ 0.2 to 0.4 percent titanium
◉ 0.4 to 0.6 percent titanium
● 0.6 to 0.8 percent titanium
● Greater than 0.8 percent titanium

Figure 76 – Geochemical map of titanium in -250 mesh till samples, Killala Lake detailed area.

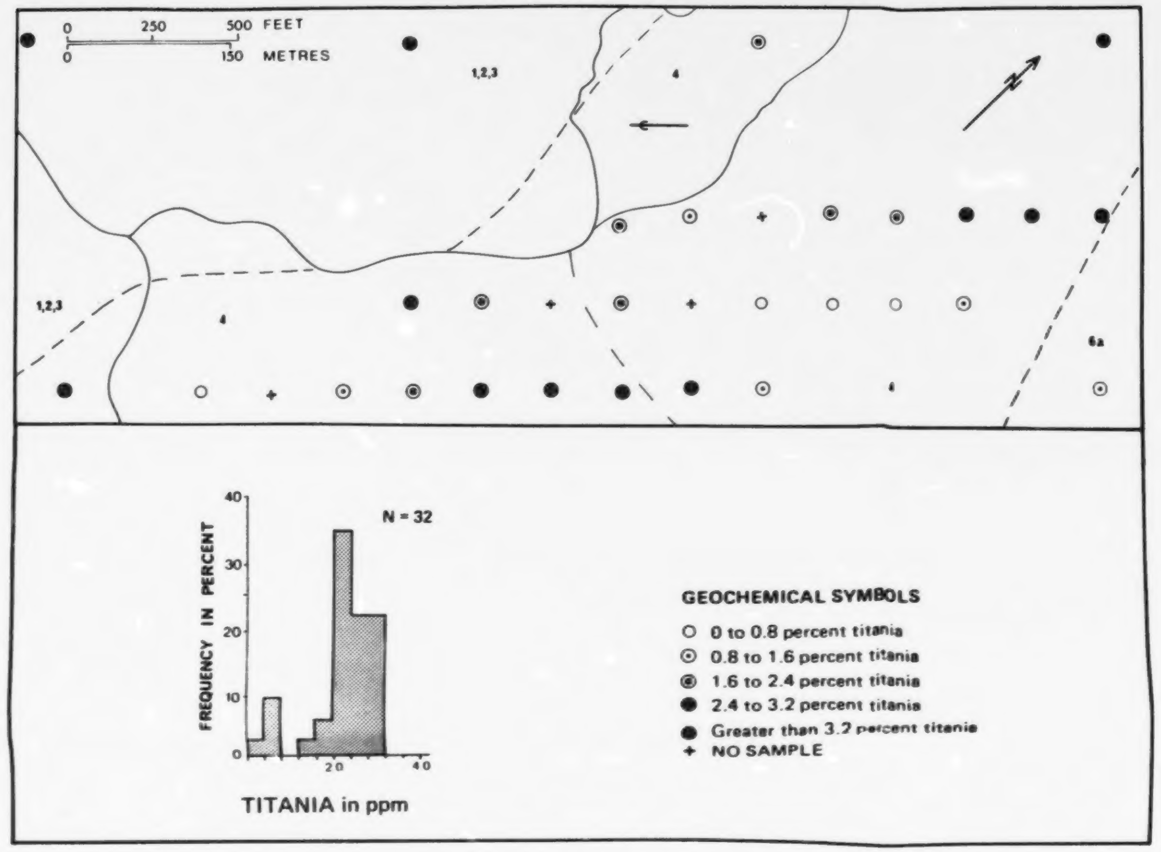

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
40
30
20
10
0
2.0
4.0
FREQUENCY IN PERCENT
N = 32
TITANIA in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 0.8 percent titania
⊙ 0.8 to 1.6 percent titania
◉ 1.6 to 2.4 percent titania
● 2.4 to 3.2 percent titania
● Greater than 3.2 percent titania
+ NO SAMPLE

Figure 77 – Geochemical map of titania in heavy mineral separates of -60 +250 mesh till samples, Killala Lake detailed area.

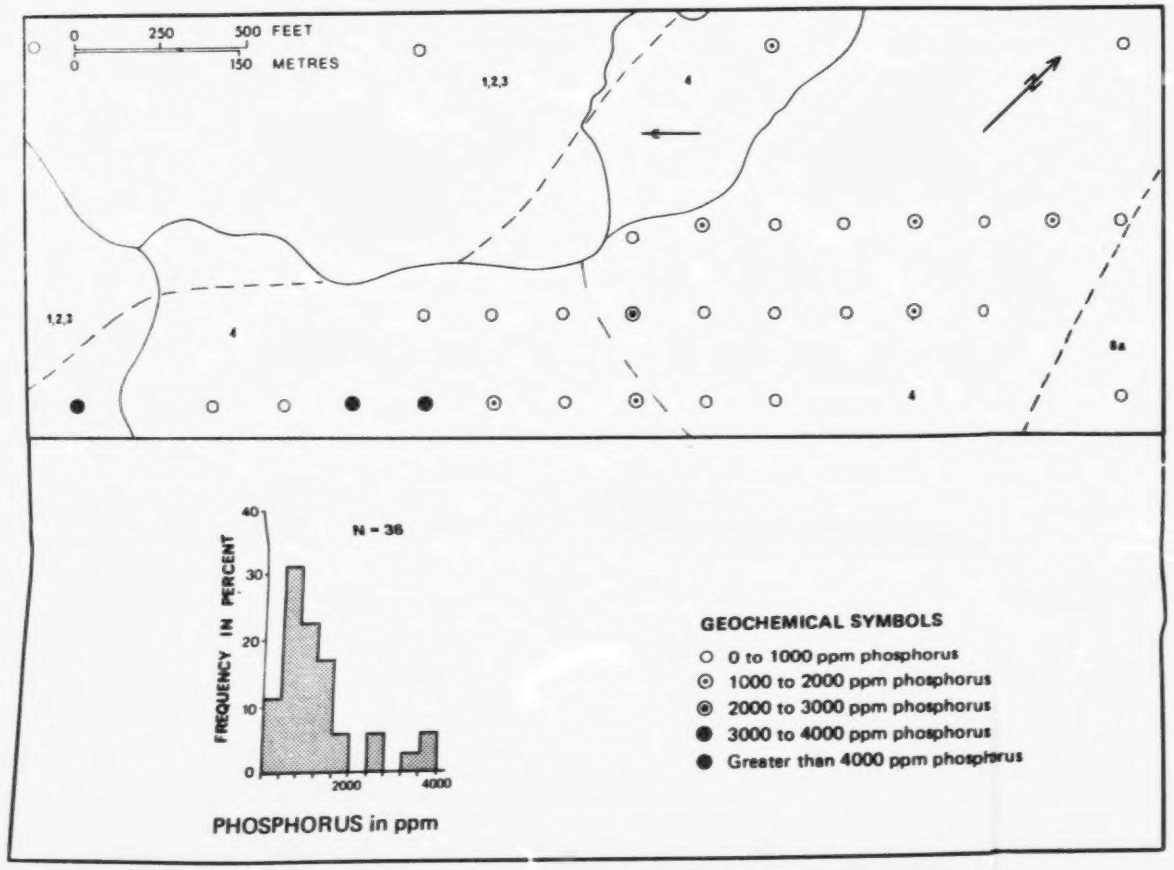

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
40
30
20
10
0
2000
4000
FREQUENCY IN PERCENT
N = 36
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 1000 ppm phosphorus
⊙ 1000 to 2000 ppm phosphorus
◉ 2000 to 3000 ppm phosphorus
● 3000 to 4000 ppm phosphorus
● Greater than 4000 ppm phosphorus

Figure 79 – Geochemical map of phosphorus in -250 mesh till samples, Killala Lake detailed

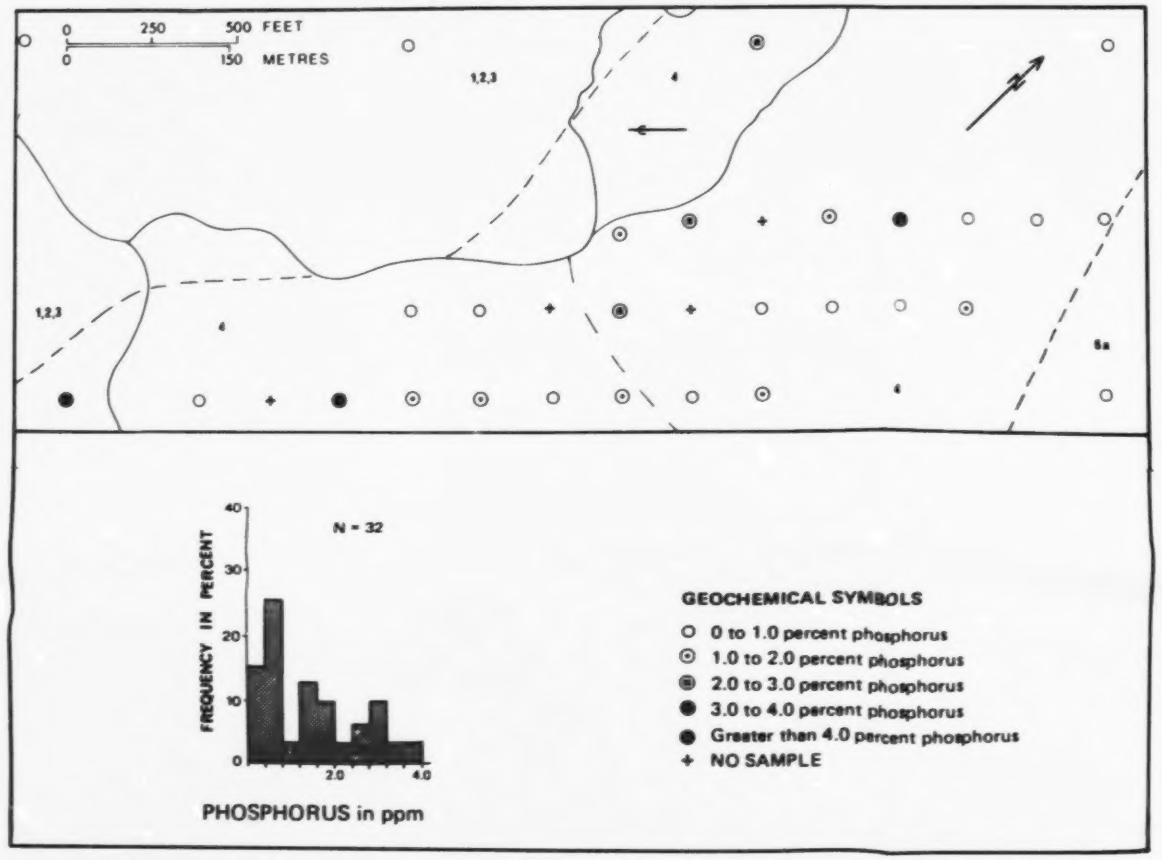

0 250 500 FEET
0 150 METRES
1,2,3
4
6a
40
30
20
10
0
2.0
4.0
FREQUENCY IN PERCENT
N = 32
PHOSPHORUS in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 1.0 percent phosphorus
⊙ 1.0 to 2.0 percent phosphorus
◉ 2.0 to 3.0 percent phosphorus
● 3.0 to 4.0 percent phosphorus
● Greater than 4.0 percent phosphorus
+ NO SAMPLE

Figure 80 – Geochemical map of phosphorus in heavy mineral separates of -60 +250 mesh till

6b Nepheline Syenite

5	Syenodiorite
4	Gabbroic Rocks
3	Mafic Intrusive Rocks
2	Felsic Intrusive Rocks
1	Metasediments
	Geological Contact (inferred, gradational)
	Fault, inferred
	Glacial Transport Direction
S	Sulphide Occurrence

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

Magnetic declination approximately 3° W, 1980.

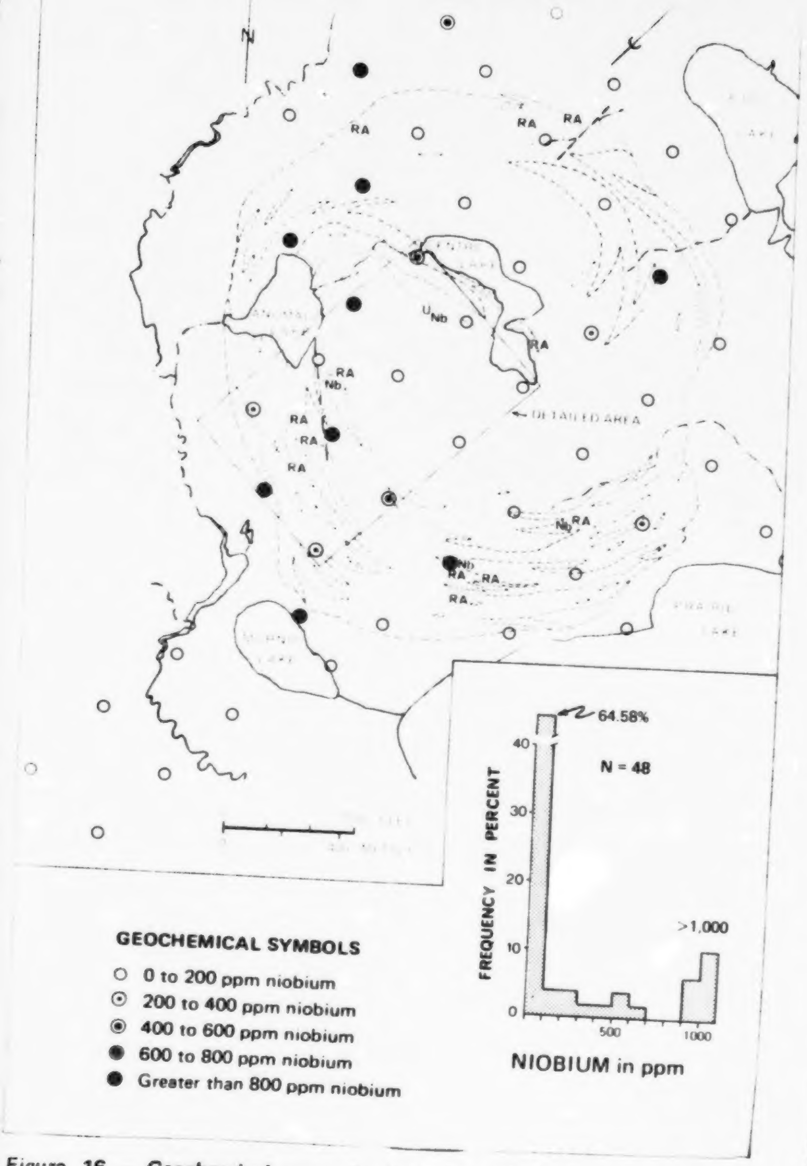


Figure 16 – Geochemical map of niobium in 'B' horizon soils, Prairie Lake area.

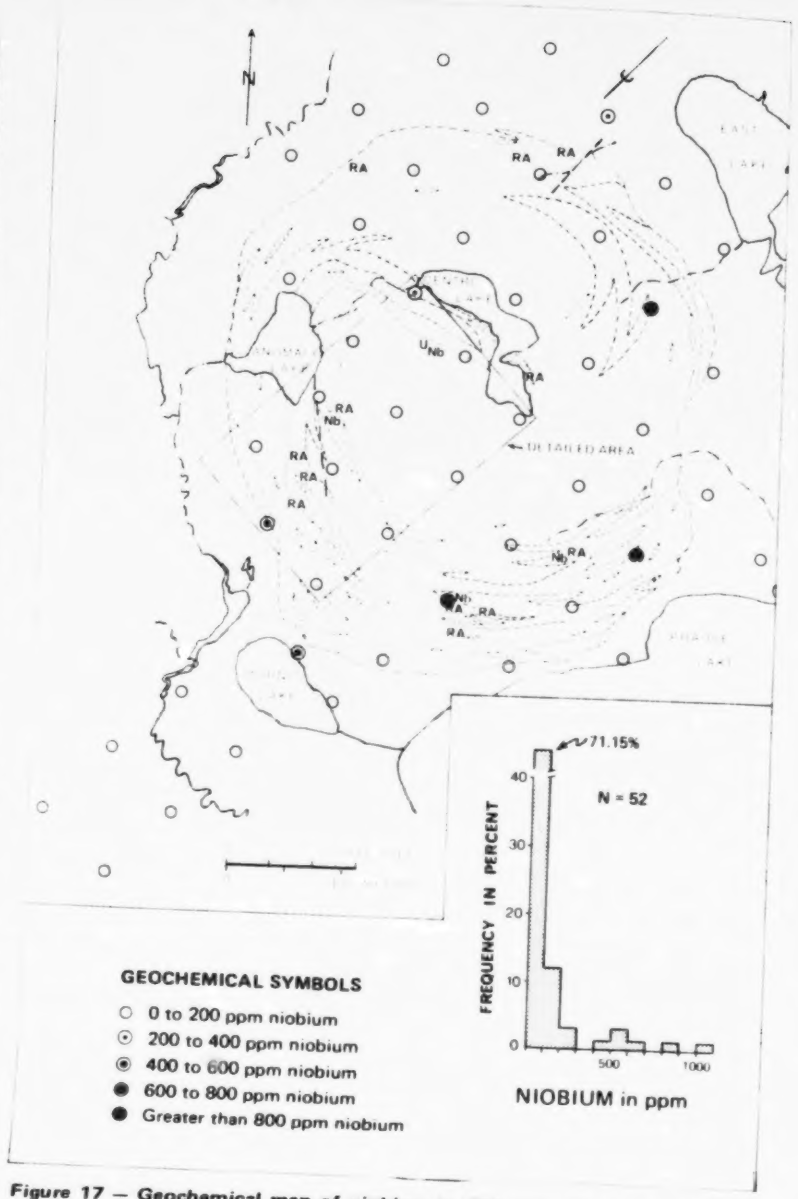


Figure 17 – Geochemical map of niobium in -250 mesh till samples, Prairie Lake area.

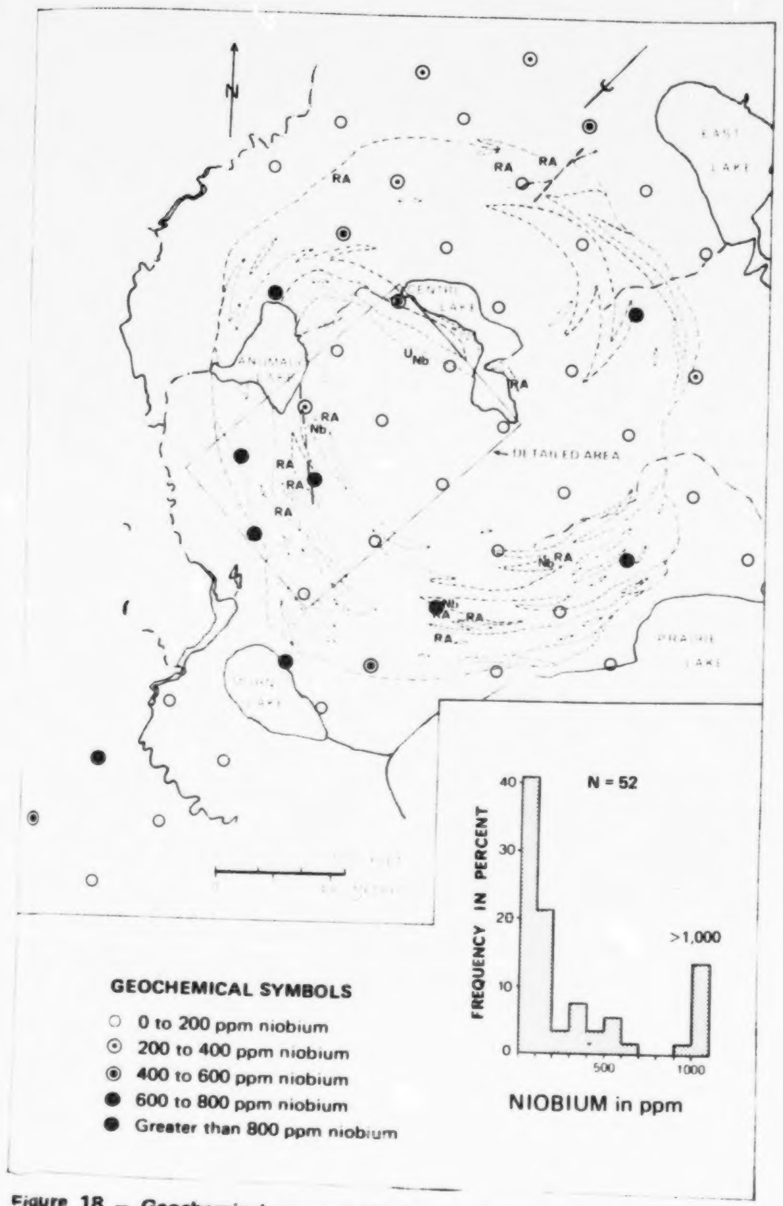


Figure 18 – Geochemical map of niobium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

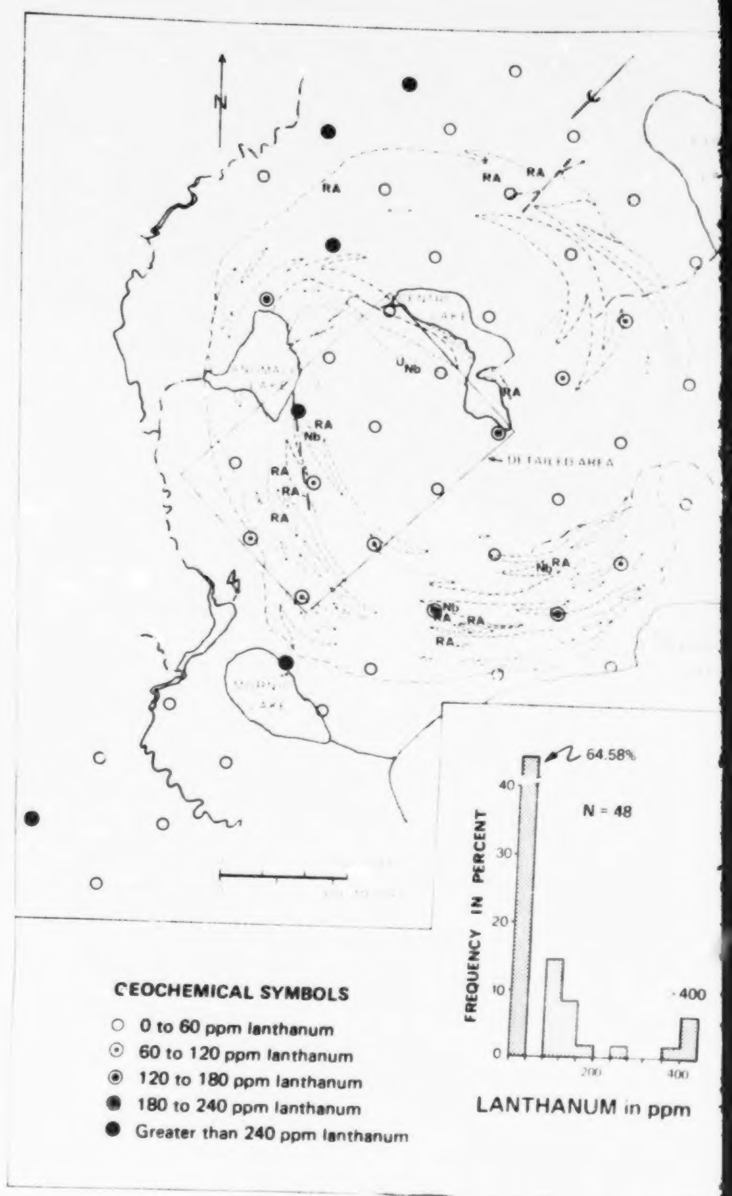
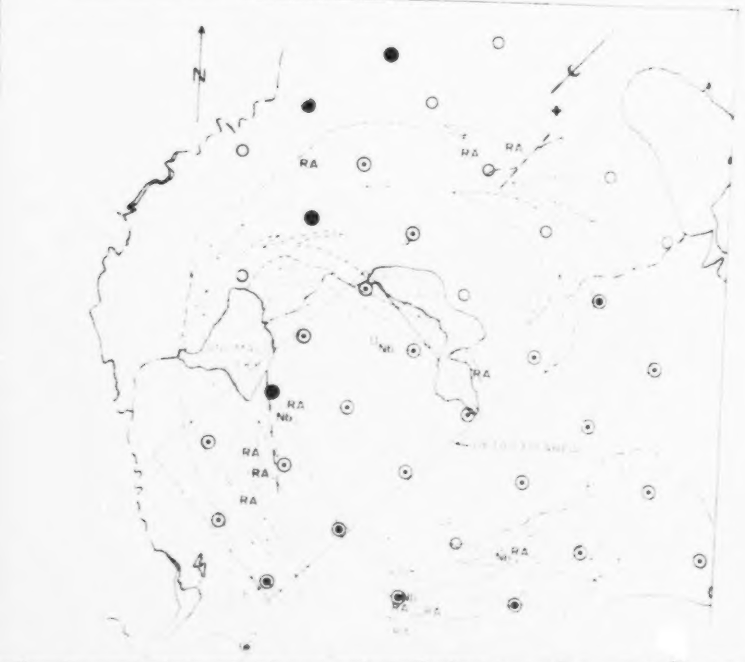
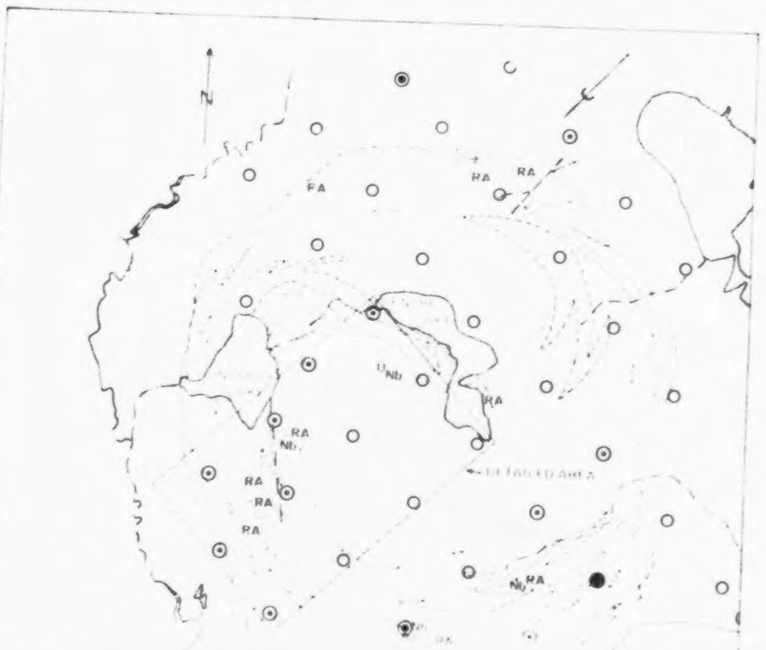
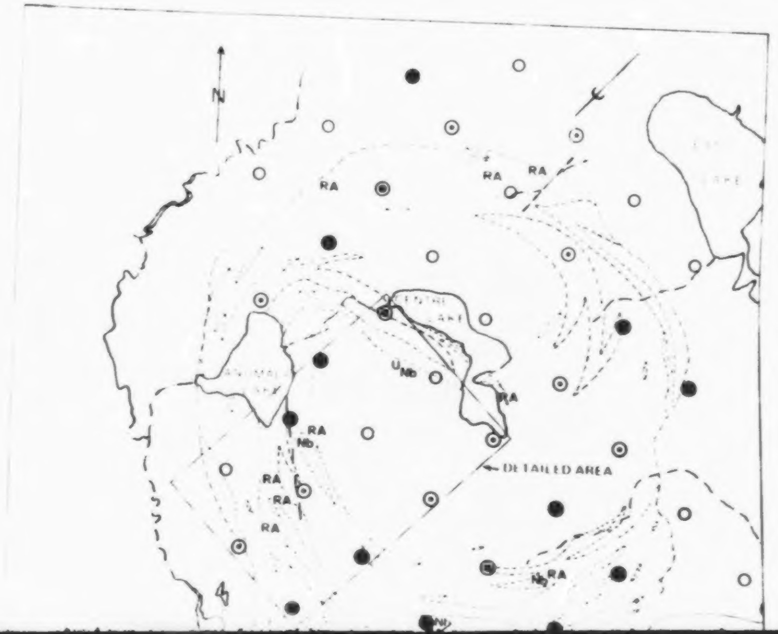


Figure 19 – Geochemical map of lanthanum in 'B' horizon soils, Prairi
Lake area.







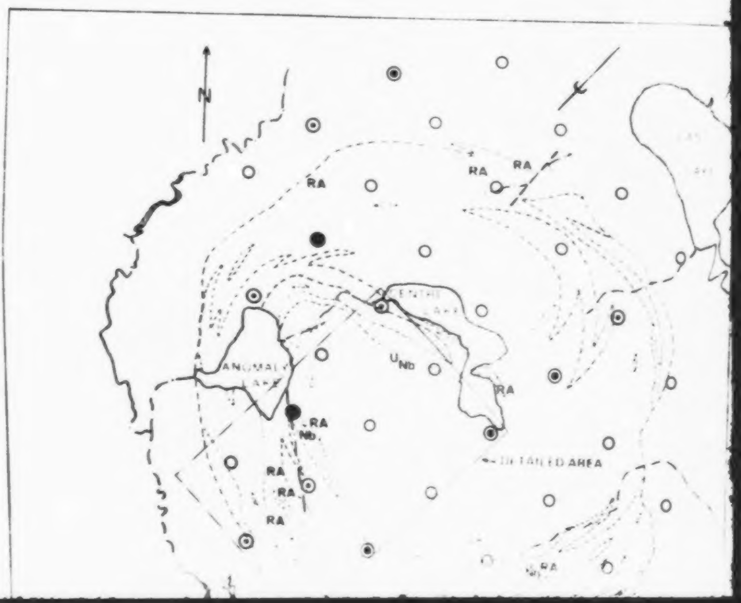
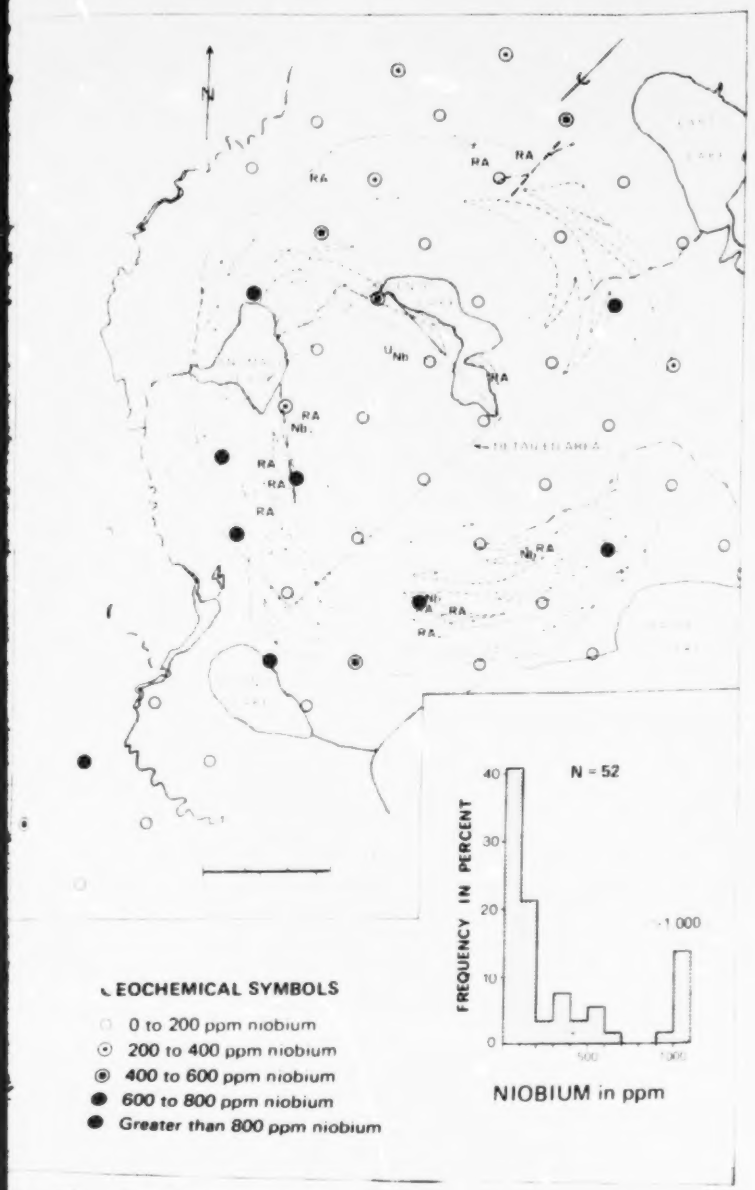


Chart A-2
Figures 15 to 30 (inclusive'



ure 18 – *Geochemical map of niobium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.*

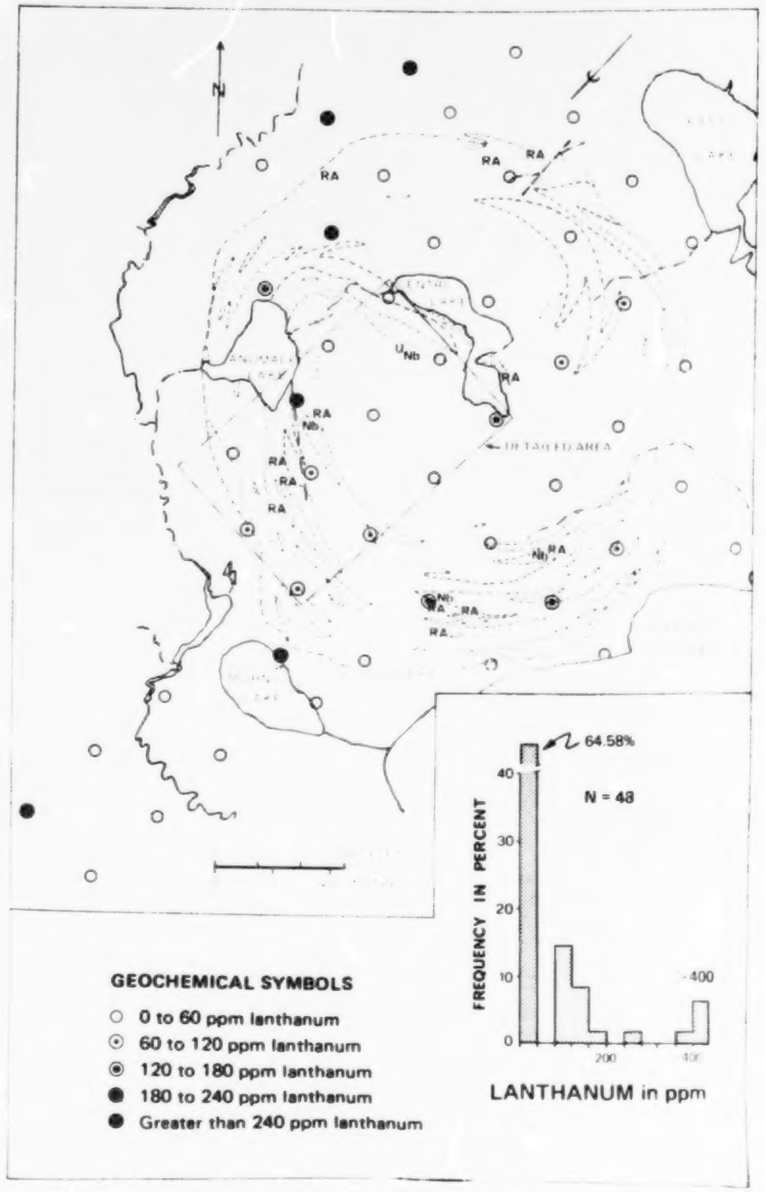


Figure 19 – Geochemical map of lanthanum in 'B' horizon soils, Prairie Lake area.

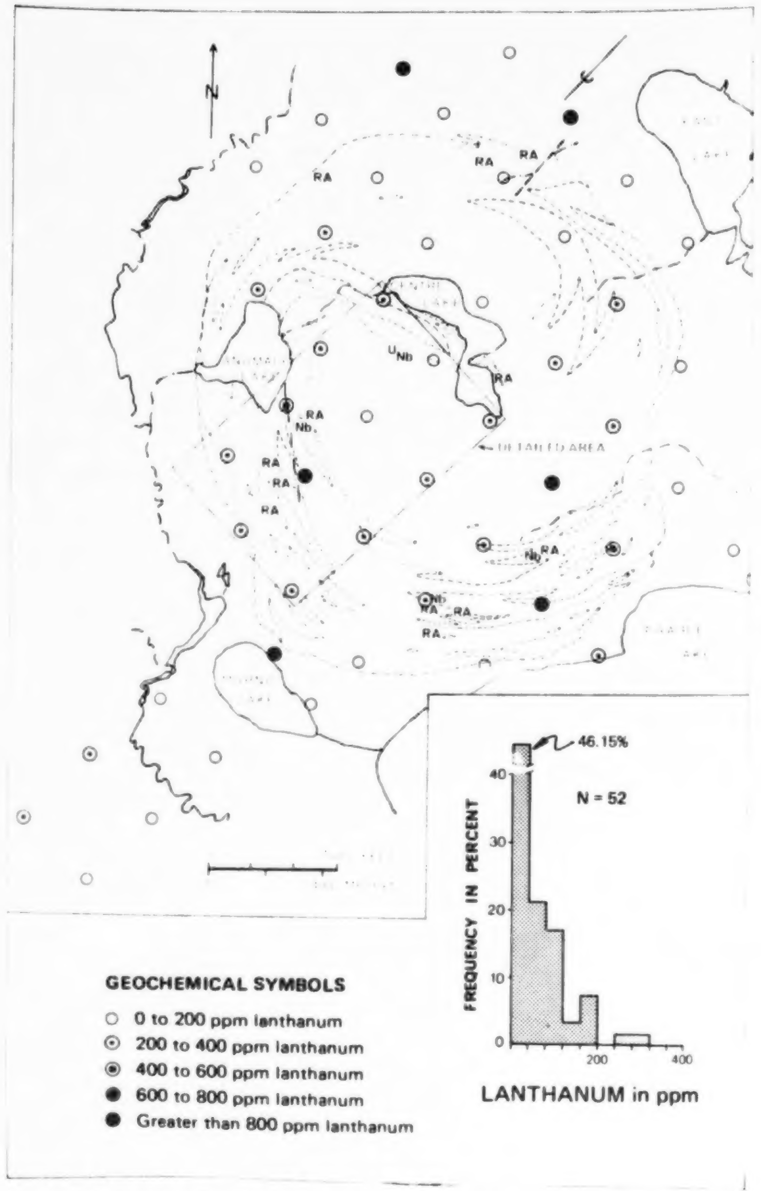


Figure 20 – Geochemical map of lanthanum in -250 mesh till samples, Prairie Lake area.

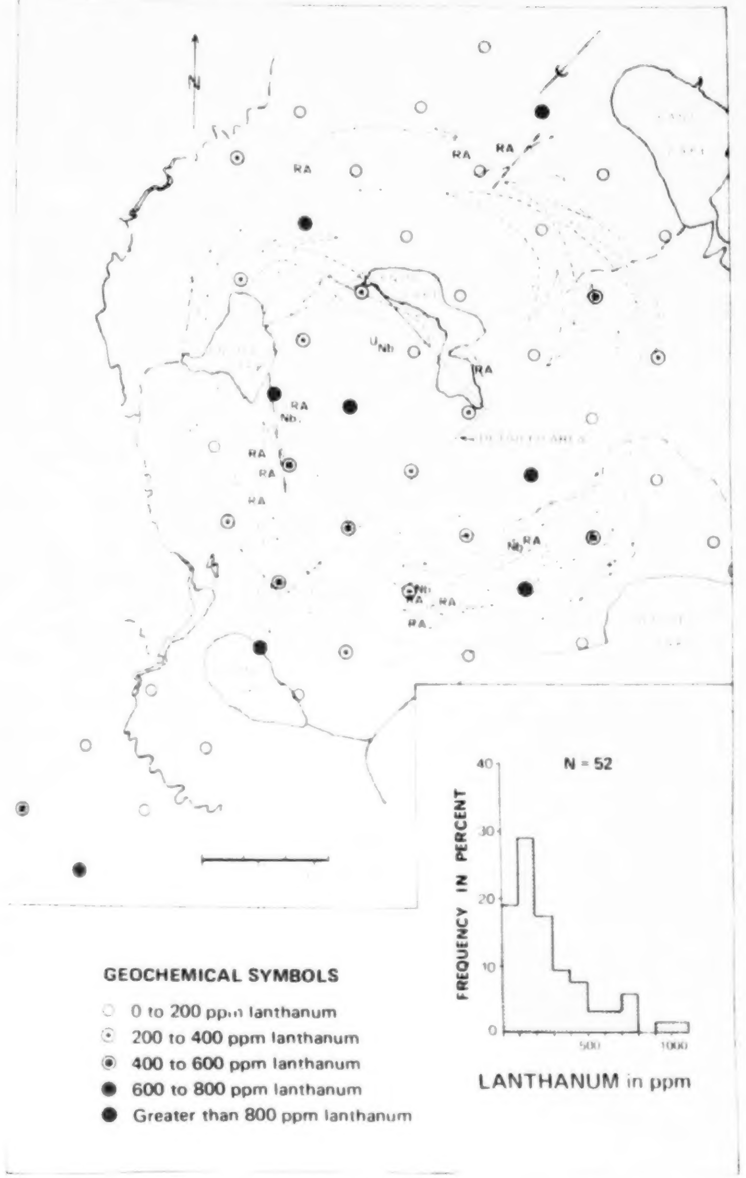
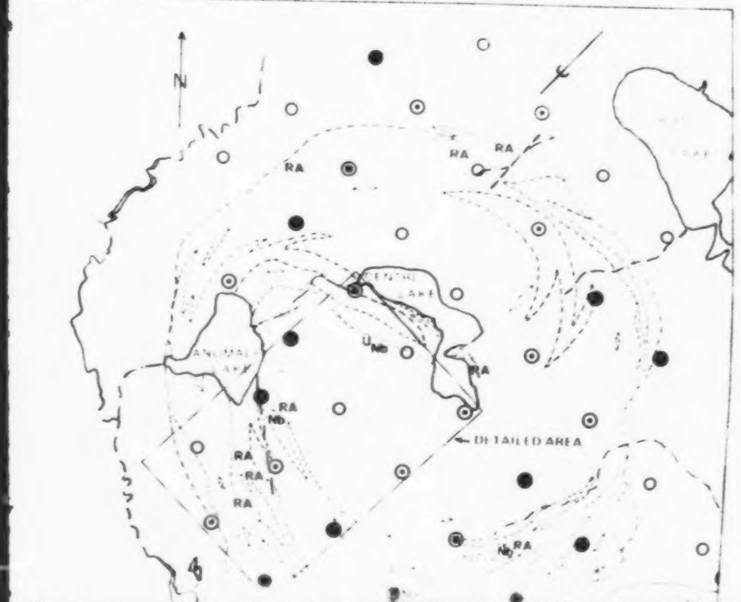
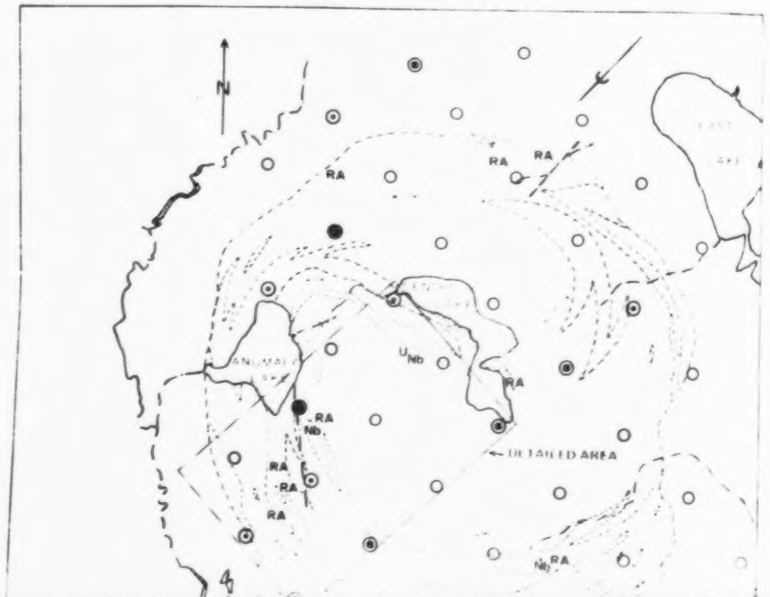
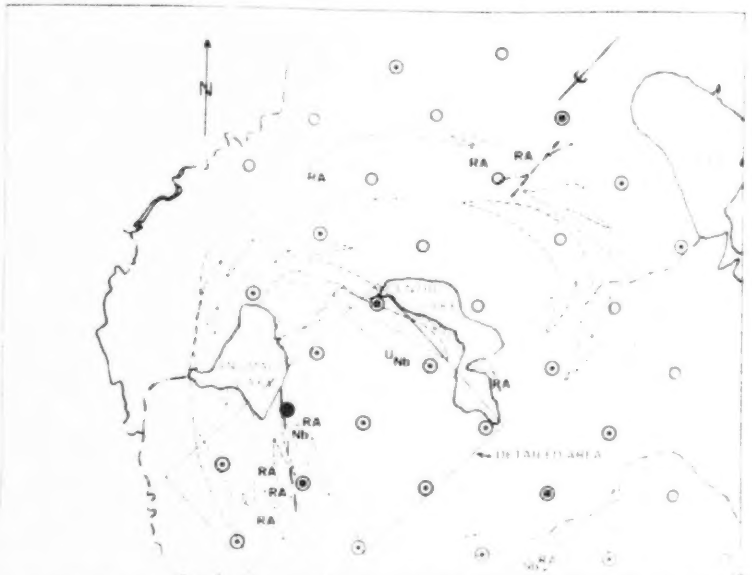
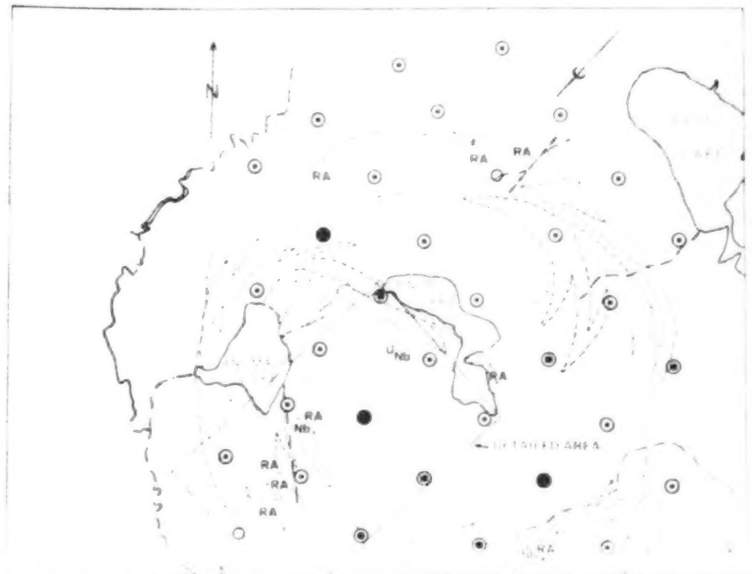


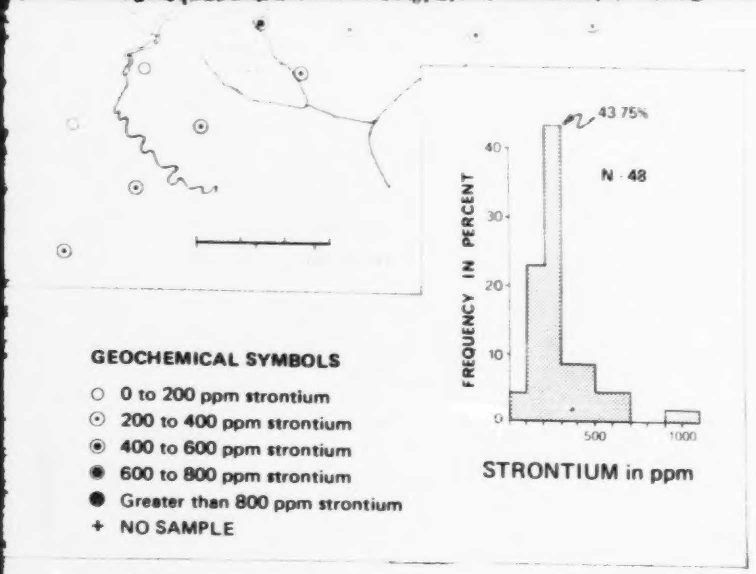
Figure 21 – Geochemical map of lanthanum in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.











igure 22 – Geochemical map of strontium in 'B' horizon soils, Prairie Lake area.

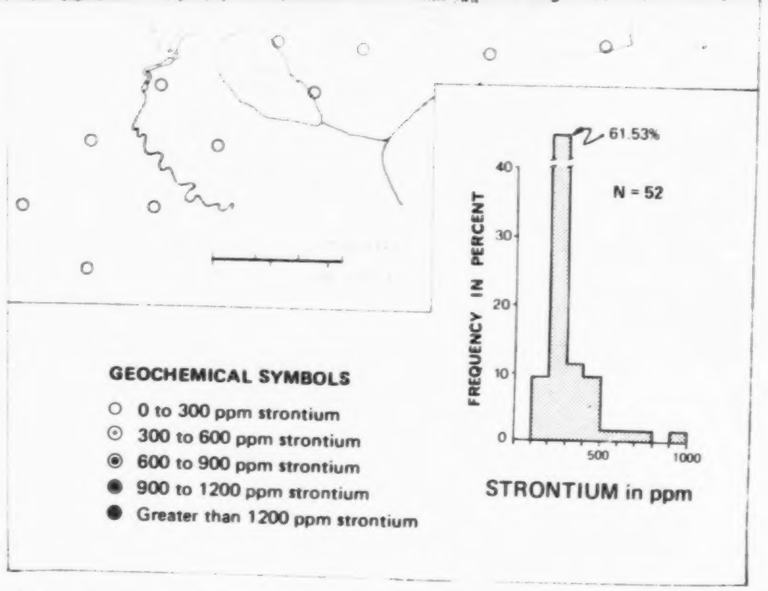

61.53%
N = 52
FREQUENCY IN PERCENT
0
10
20
30
40
500
1000
STRONTIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 300 ppm strontium
⊙ 300 to 600 ppm strontium
◉ 600 to 900 ppm strontium
● 900 to 1200 ppm strontium
● Greater than 1200 ppm strontium

Figure 23 – Geochemical map of strontium in -250 mesh till samples, Prairie Lake area.

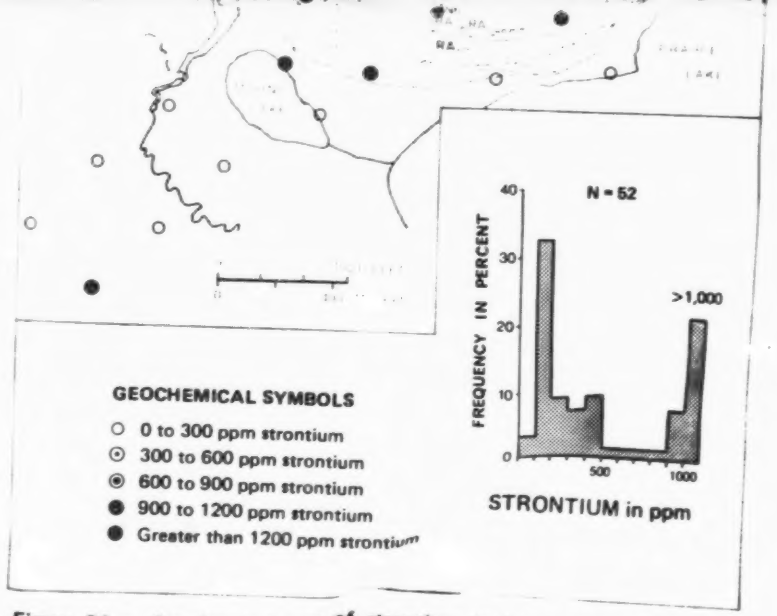


Figure 24 – Geochemical map of strontium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

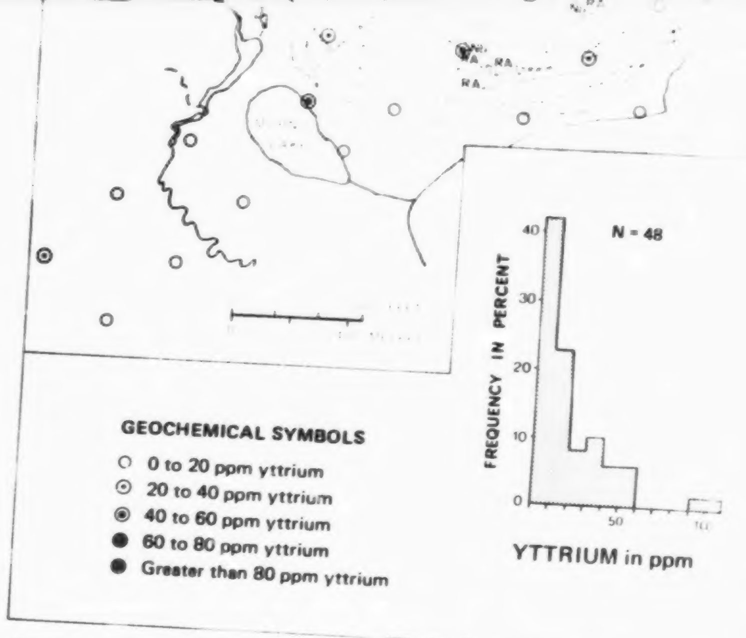
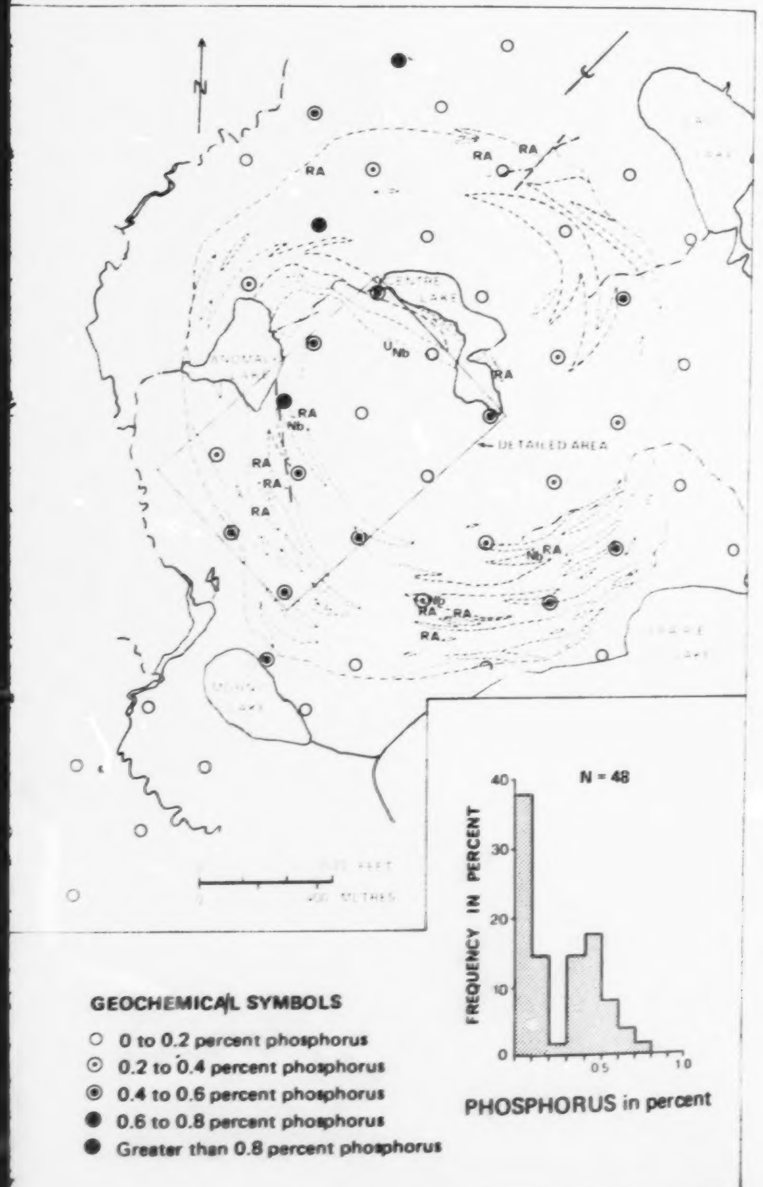


Figure 25 – Geochemical map of yttrium in 'B' horizon soils, Prairie Lake area.



ure 28 – Geochemical map of phosphorus in 'B' horizon soils, Prairie Lake area.

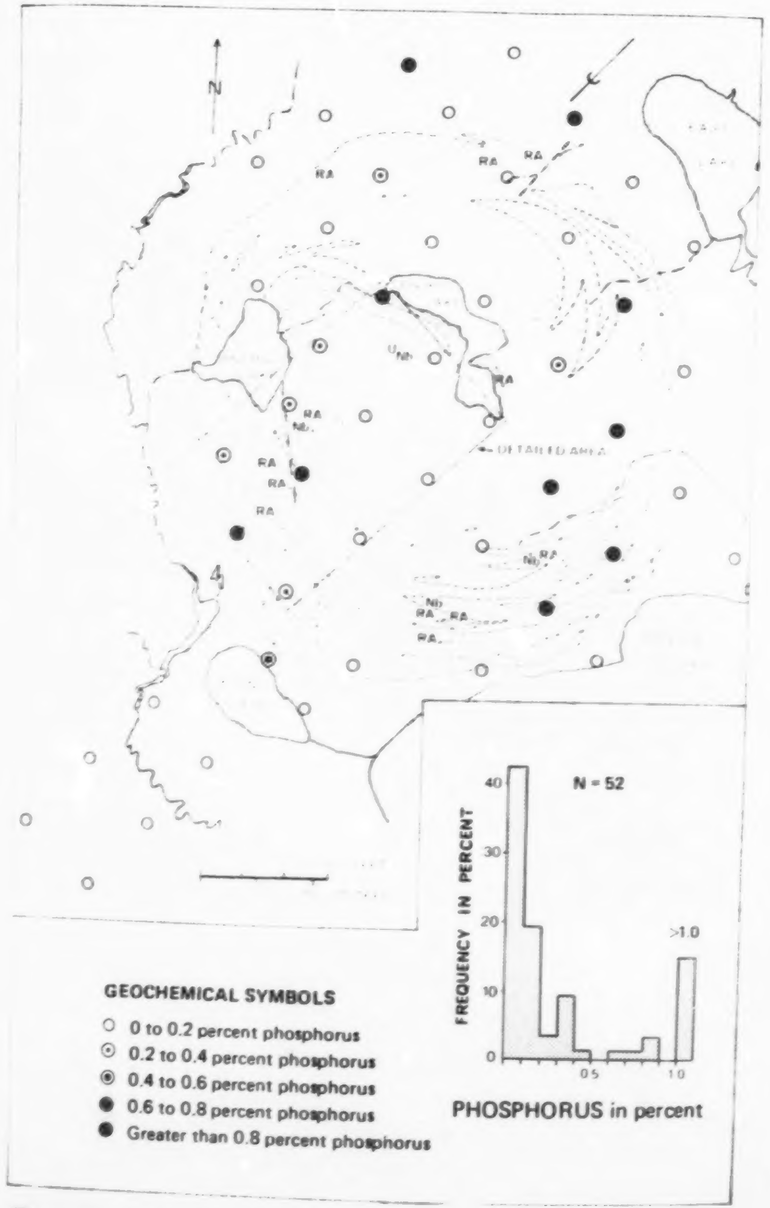

N
RA
RA
RA
U
Nb
RA
Nb
RA
RA
RA
RA
DETAILED AREA
Nb
RA
Nb
RA
N = 52
>1.0
FREQUENCY IN PERCENT
0
10
20
30
40
0.5
1.0
PHOSPHORUS in percent
GEOCHEMICAL SYMBOLS
○ 0 to 0.2 percent phosphorus
⊙ 0.2 to 0.4 percent phosphorus
◉ 0.4 to 0.6 percent phosphorus
● 0.6 to 0.8 percent phosphorus
● Greater than 0.8 percent phosphorus

Figure 29 – Geochemical map of phosphorus in -250 mesh till samples, Prairie Lake area.

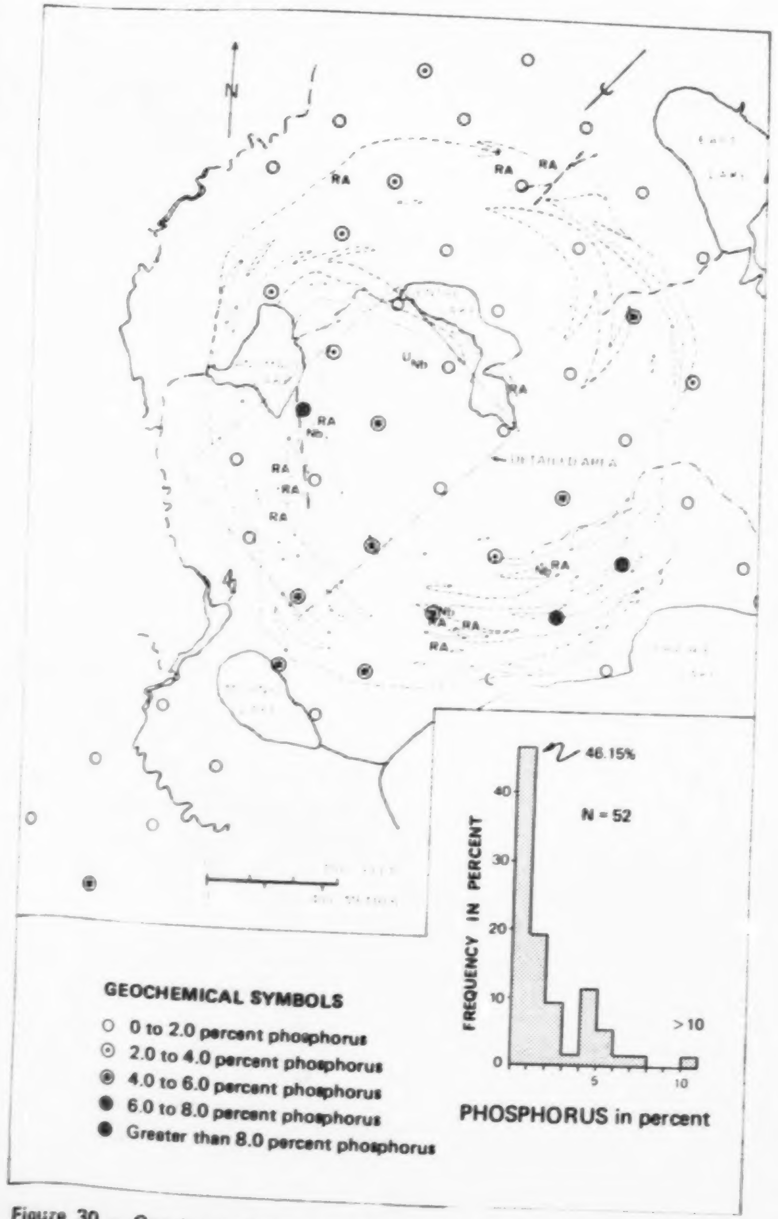

N
RA
RA
RA
U
Nb
RA
RA
RA
RA
DETAILED AREA
RA
RA
46.15%
N = 52
>10
FREQUENCY IN PERCENT
0
10
20
30
40
5
10
PHOSPHORUS in percent
GEOCHEMICAL SYMBOLS
○ 0 to 2.0 percent phosphorus
⊙ 2.0 to 4.0 percent phosphorus
◉ 4.0 to 6.0 percent phosphorus
● 6.0 to 8.0 percent phosphorus
● Greater than 8.0 percent phosphorus

Figure 30 – Geochemical map of phosphorus in heavy mineral separates of -60 +250 mesh till

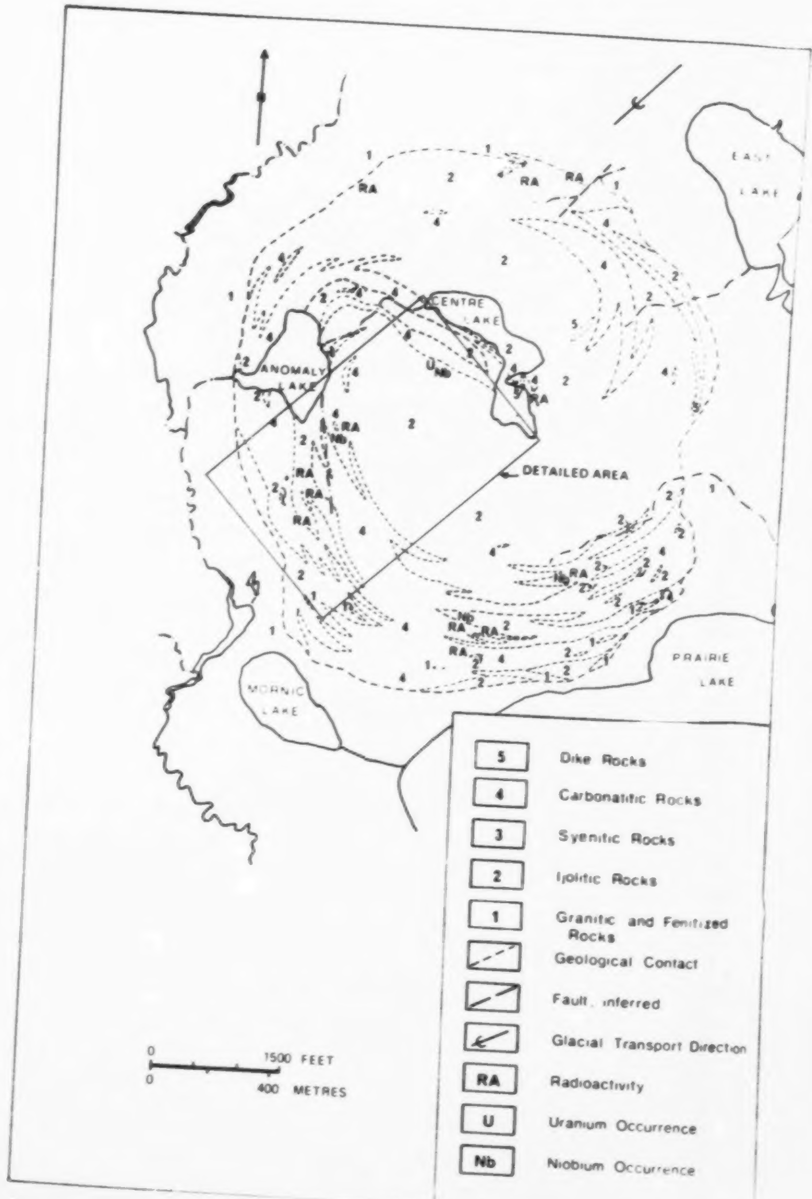


Figure 15

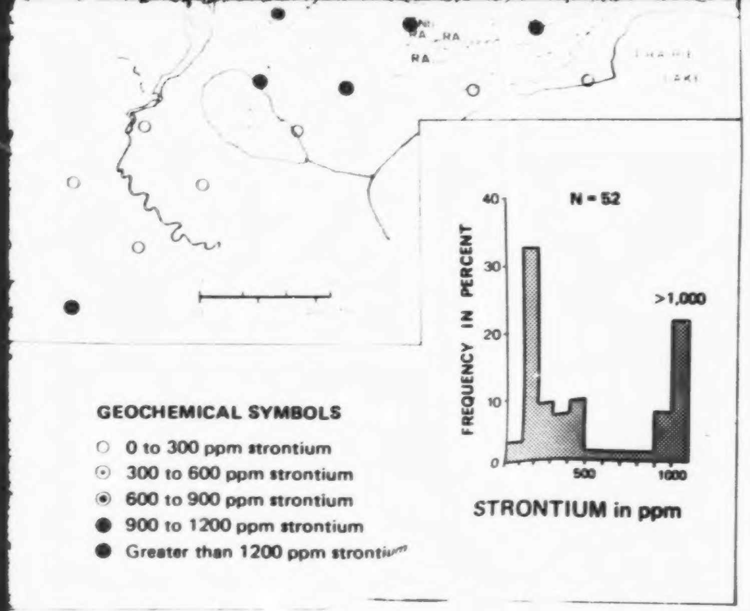

RA
N = 52
>1,000
FREQUENCY IN PERCENT
40
30
20
10
0
500
1000
STRONTIUM in ppm
GEOCHEMICAL SYMBOLS
○ 0 to 300 ppm strontium
⊙ 300 to 600 ppm strontium
◉ 600 to 900 ppm strontium
● 900 to 1200 ppm strontium
● Greater than 1200 ppm strontium

Figure 24 – Geochemical map of strontium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

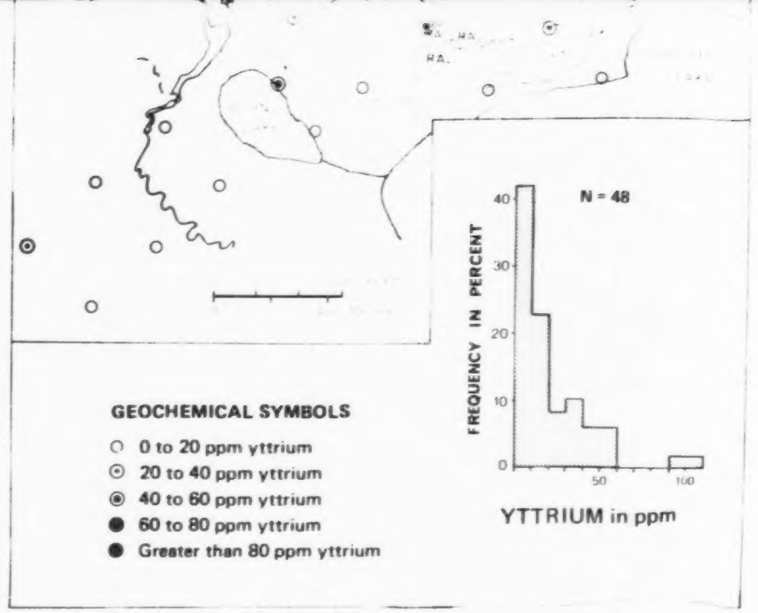


Figure 25 – Geochemical map of yttrium in 'B' horizon soils, Prairie Lake area.

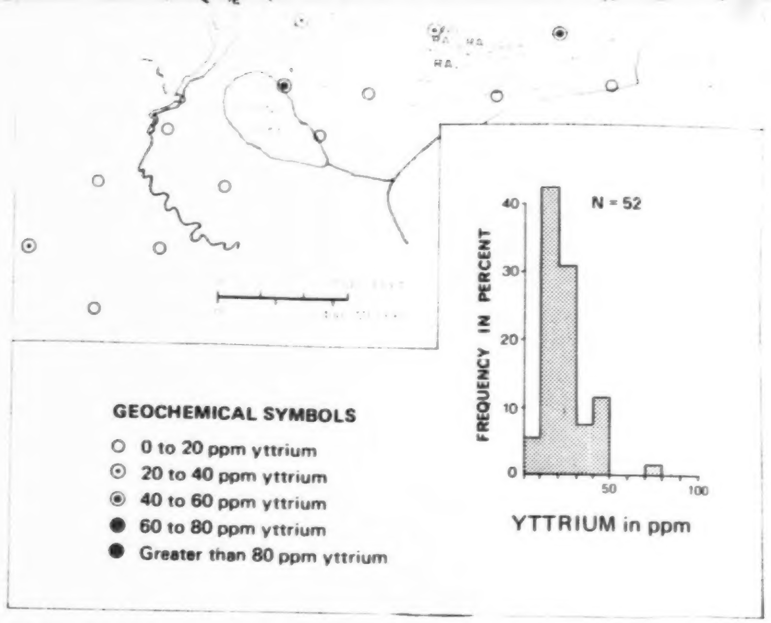


Figure 26 – Geochemical map of yttrium in -250 mesh till samples, Prairie Lake area.

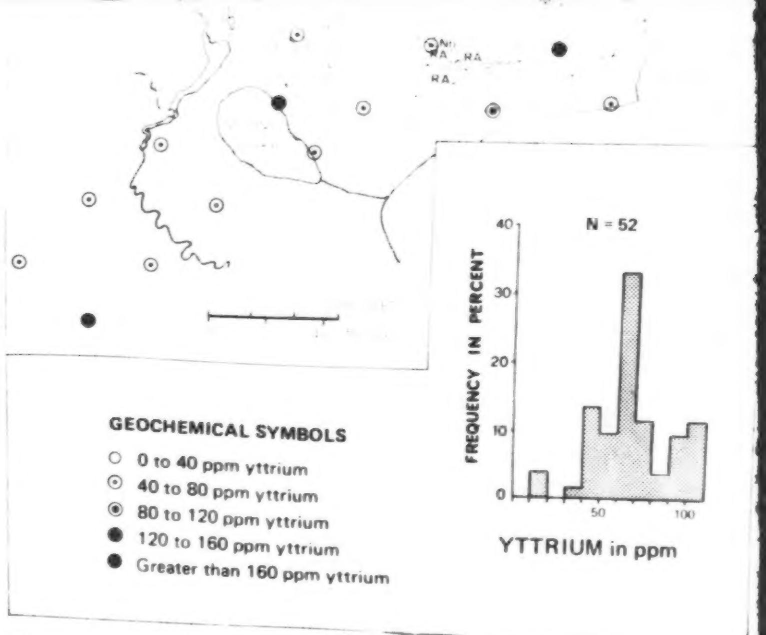


Figure 27 – Geochemical map of yttrium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake area.

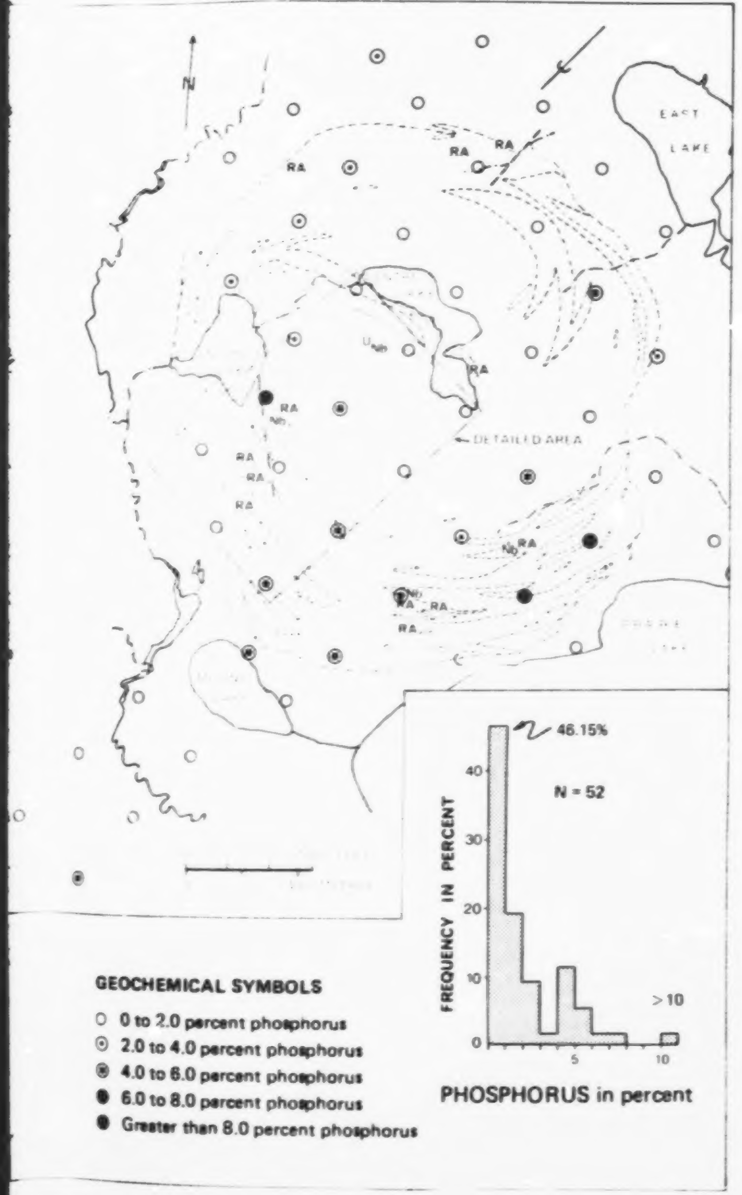

N
EAST
LAKE
RA
U
Nb
DETAILED AREA
46.15%
N = 52
>10
FREQUENCY IN PERCENT
40
30
20
10
0
5
10
PHOSPHORUS in percent
GEOCHEMICAL SYMBOLS
○ 0 to 2.0 percent phosphorus
⊙ 2.0 to 4.0 percent phosphorus
◉ 4.0 to 6.0 percent phosphorus
● 6.0 to 8.0 percent phosphorus
● Greater than 8.0 percent phosphorus

Figure 30 – Geochemical map of phosphorus in heavy mineral separates

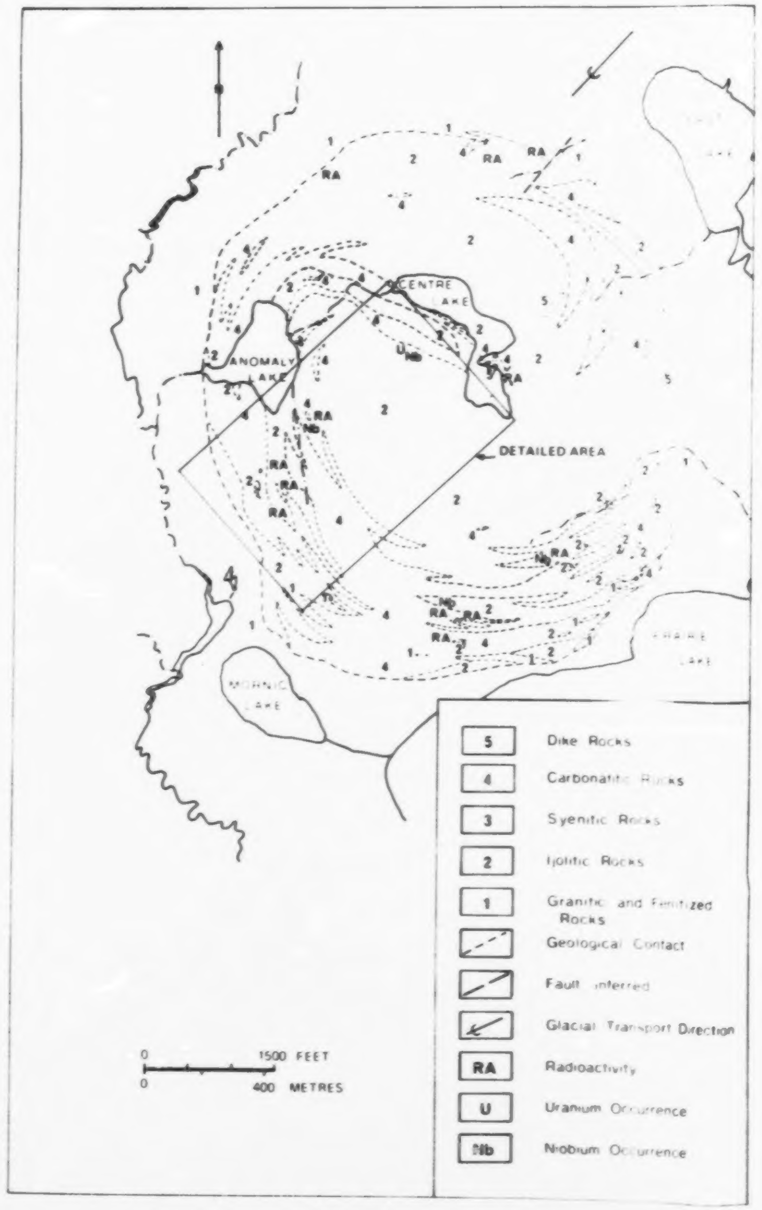


Figure 15 – Bedrock geology, Prairie Lake area.

CHART A–2

Geochemical Distribution of NIOBIUM, LANTHANUM, STRONTIUM YTTRIUM, AND PHOSPHORUS IN OVERBURDEN

PRAIRIE LAKE AREA

District of Thunder Bay

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

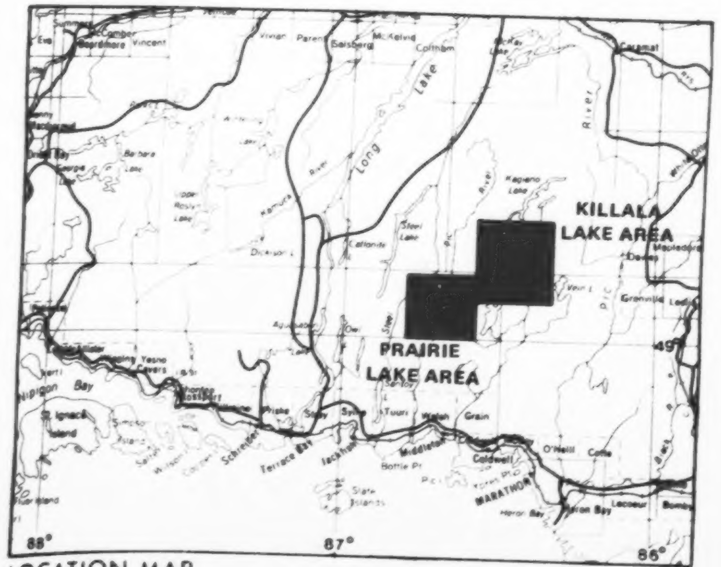
Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from unpublished geological map prepared for Newmont Mining Corporation of Canada Limited.

Magnetic declination approximately 3° W, 1980.



LOCATION MAP

Scale 1:1 584 000

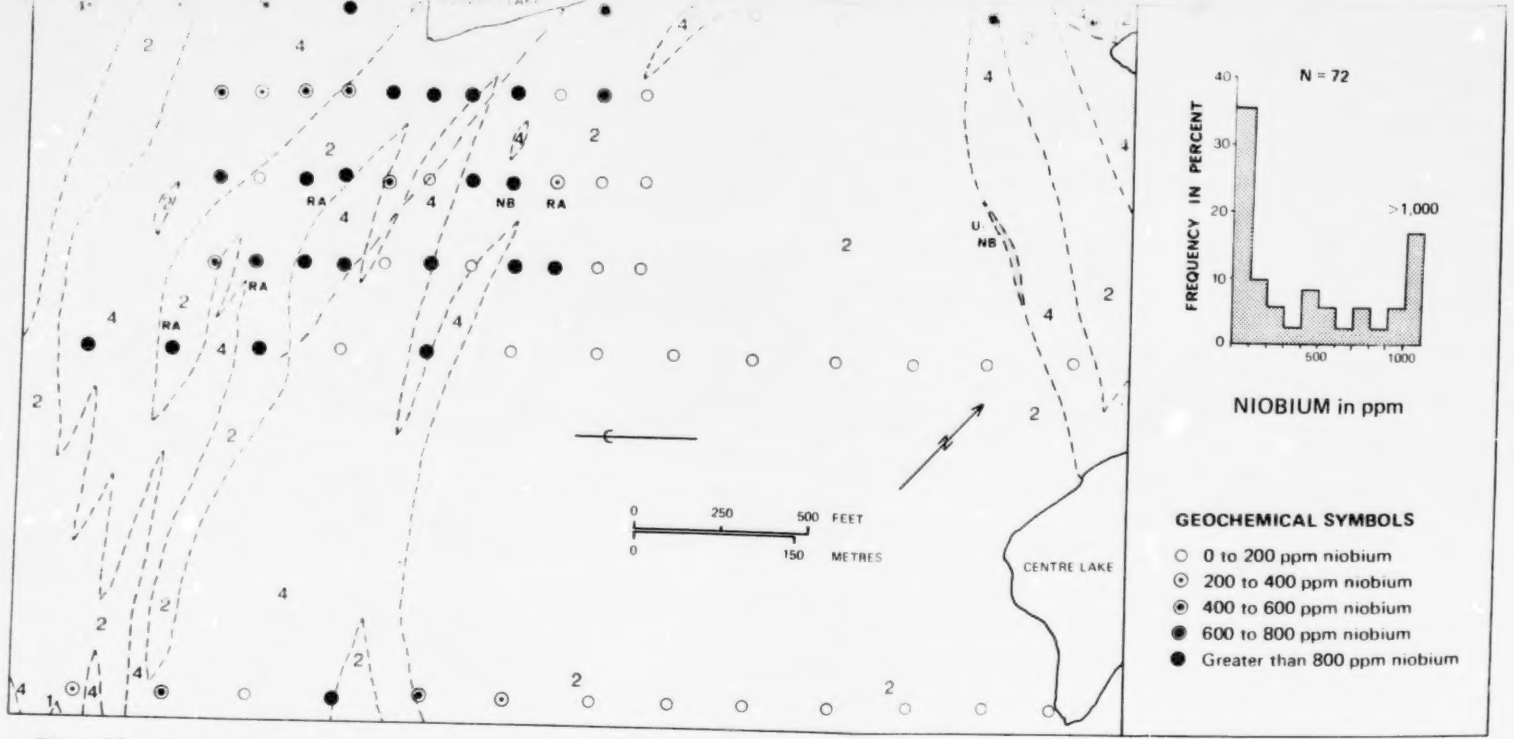


Figure 43. – Geochemical map of niobium in 'B' horizon soils, Prairie Lake detailed area.

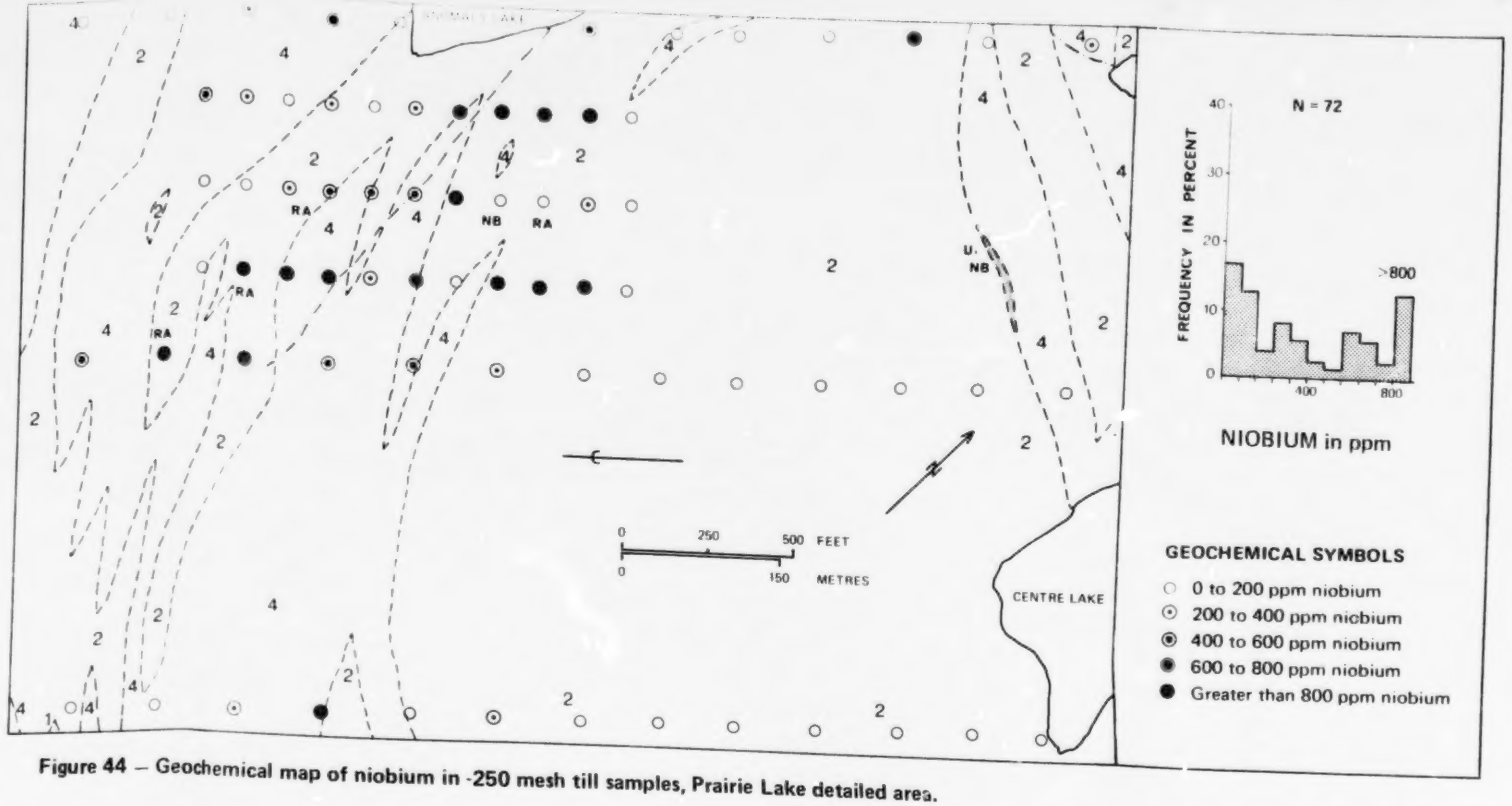


Figure 44 – Geochemical map of niobium in -250 mesh till samples, Prairie Lake detailed area.

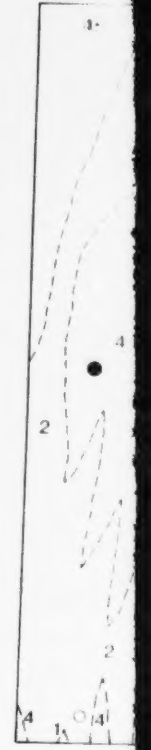


Figure 4

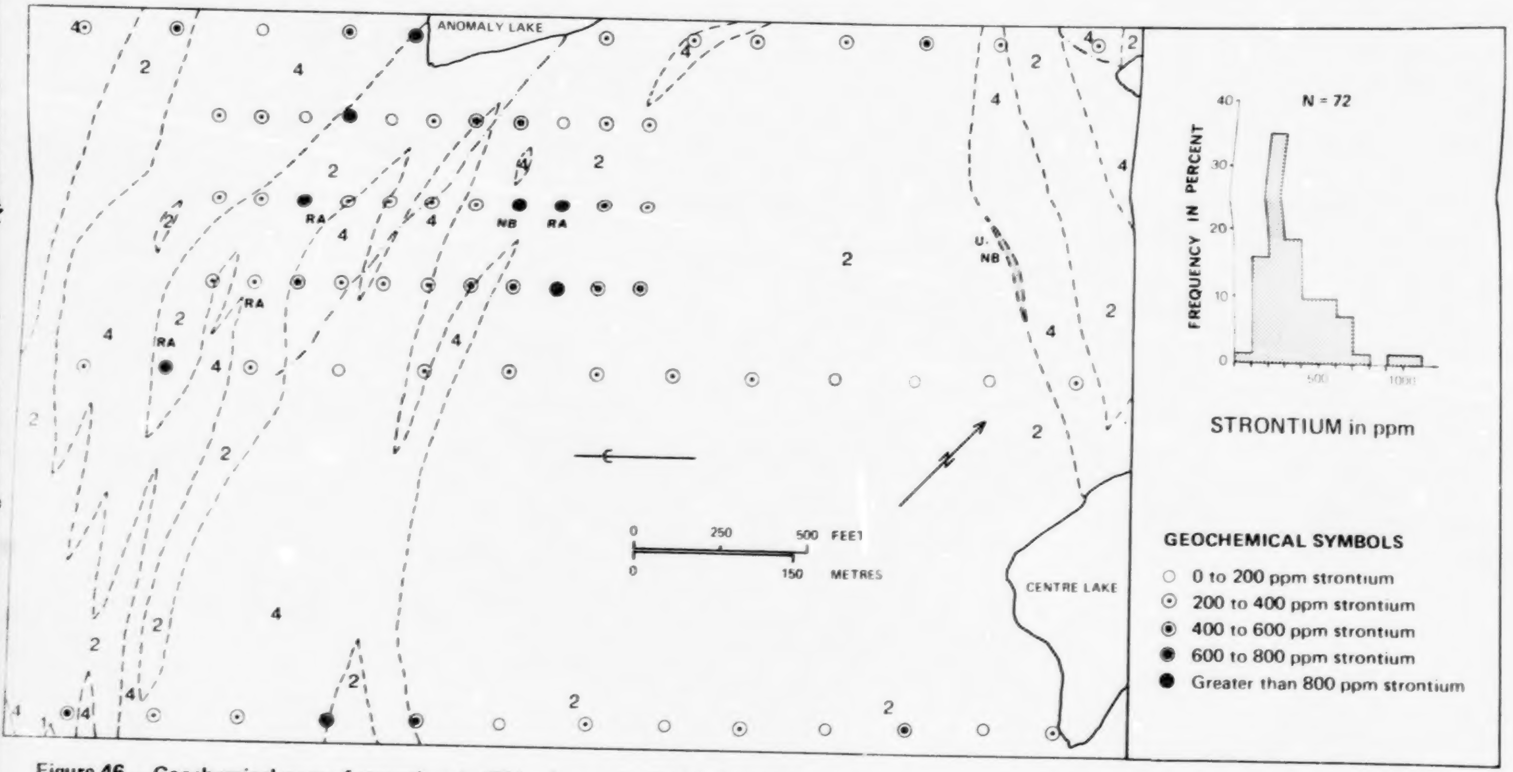


Figure 46 – Geochemical map of strontium in 'B' horizon soils, Prairie Lake detailed area.

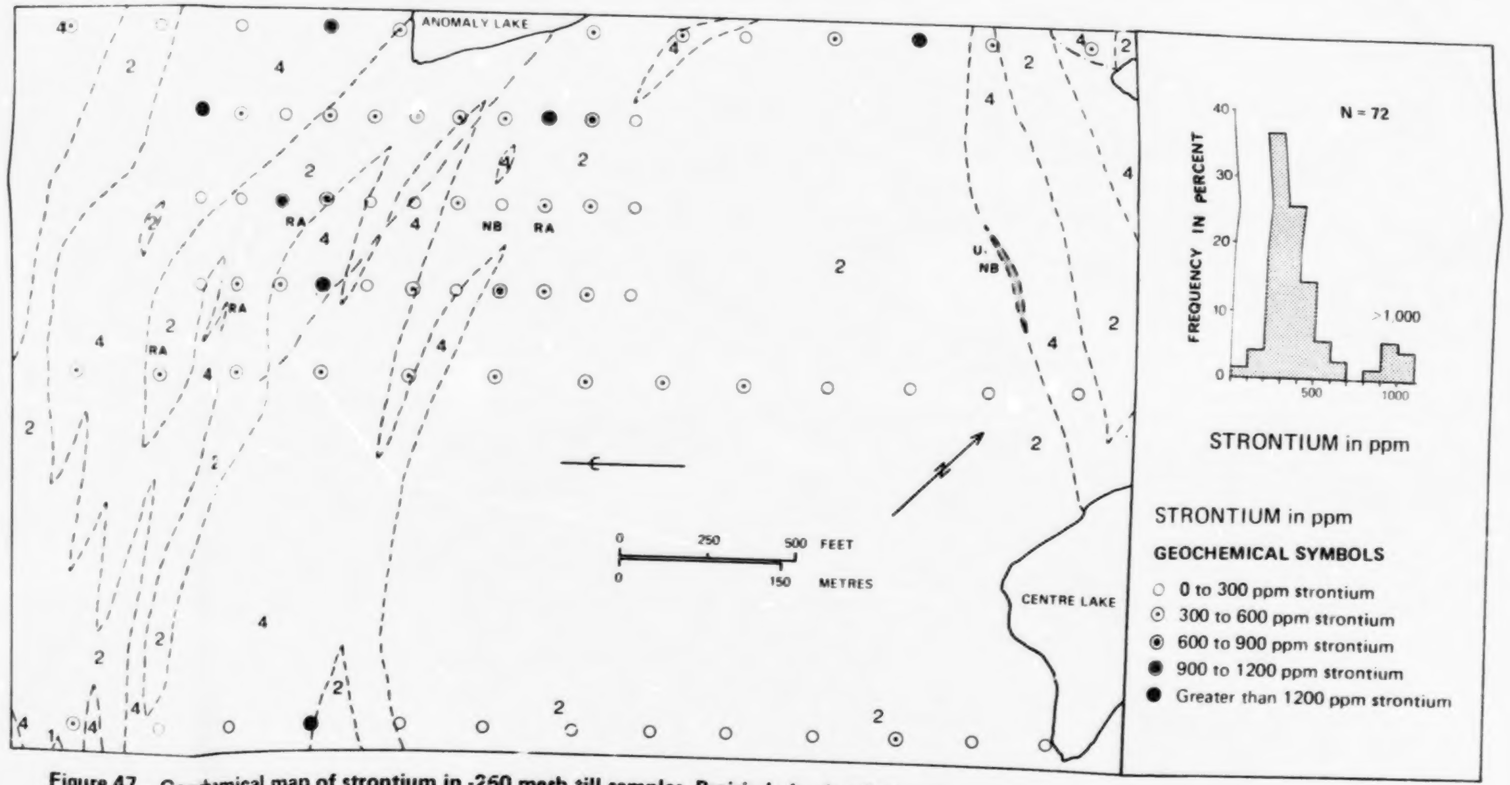


Figure 47 – Geochemical map of strontium in -250 mesh till samples, Prairie Lake detailed area.

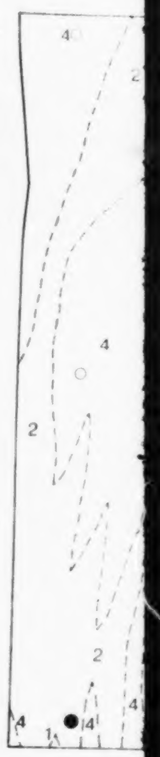
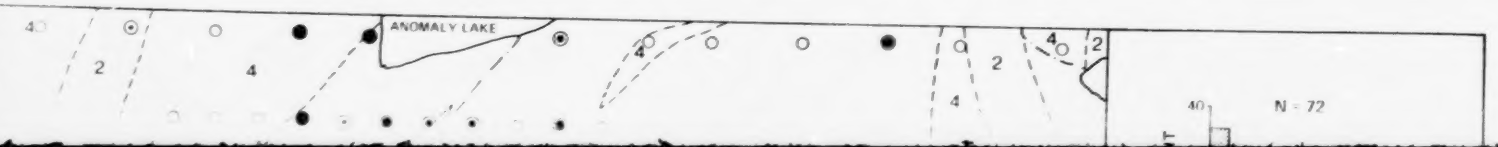
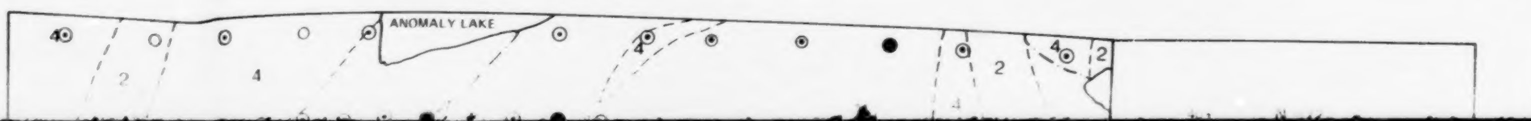
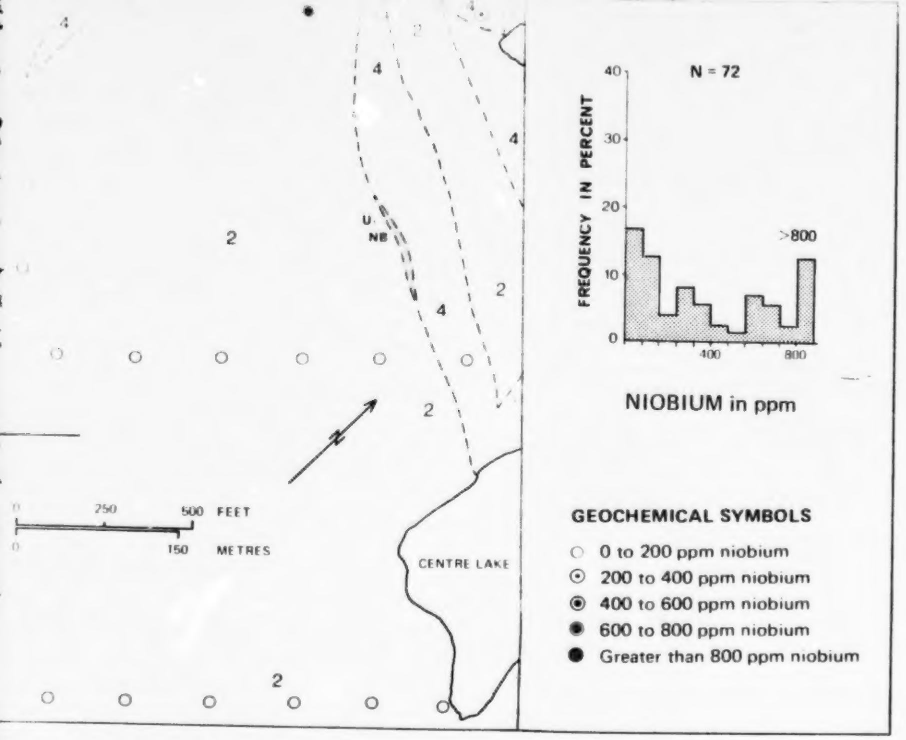


Figure 48 –





Figures 43 to 54 (inclusive)



amples, Prairie Lake detailed area.

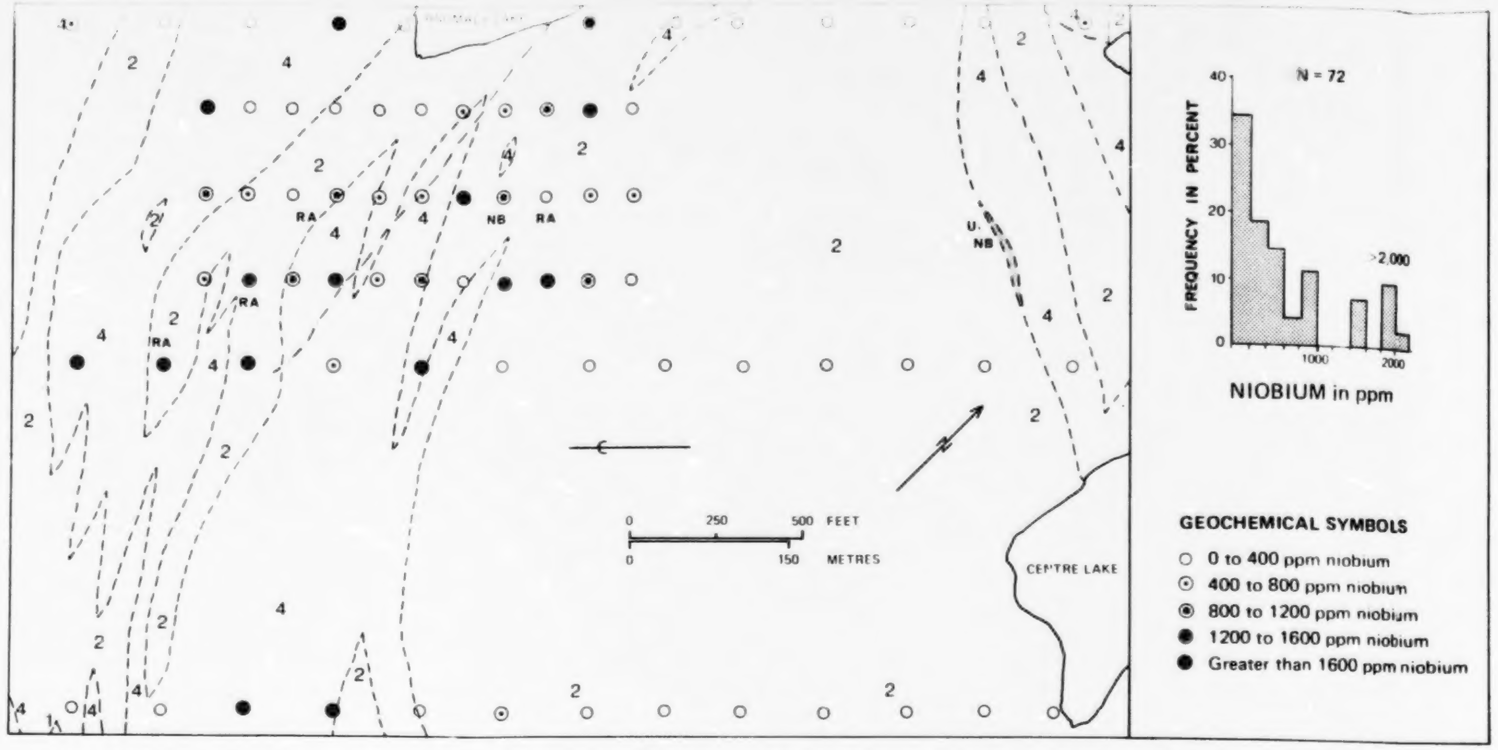


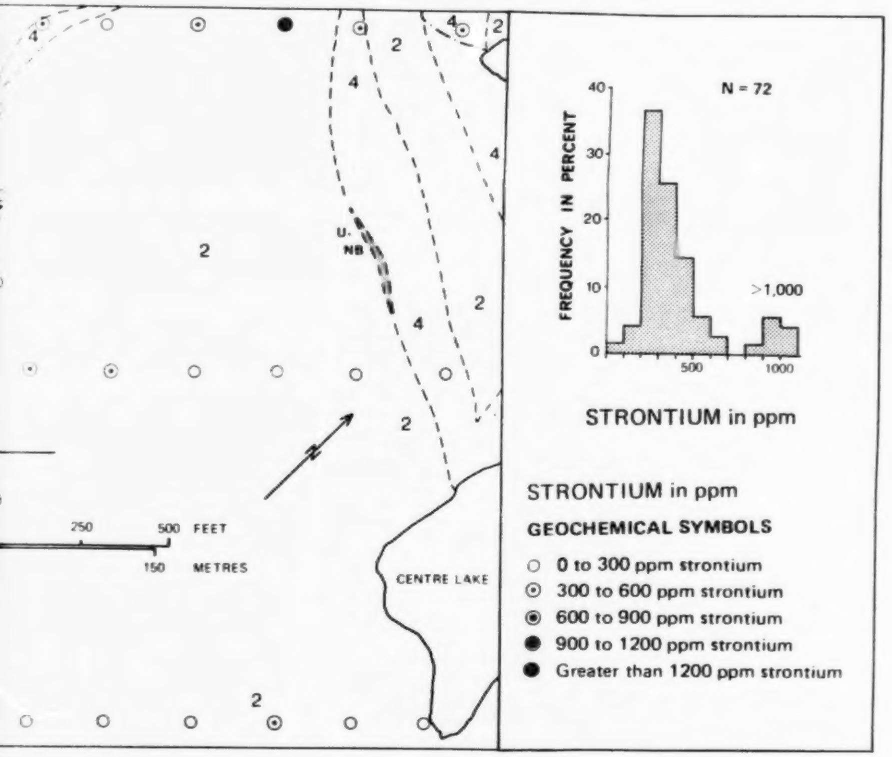
Figure 45 – Geochemical map of niobium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.

CHART B-2

Geochemical Distribution of NIOBIUM, STRONTIUM, LANTHANUM, AND YTTRIUM IN OVERBURDEN

PRAIRIE LAKE DETAILED AREA

District of Thunder Bay



amples, Prairie Lake detailed area.

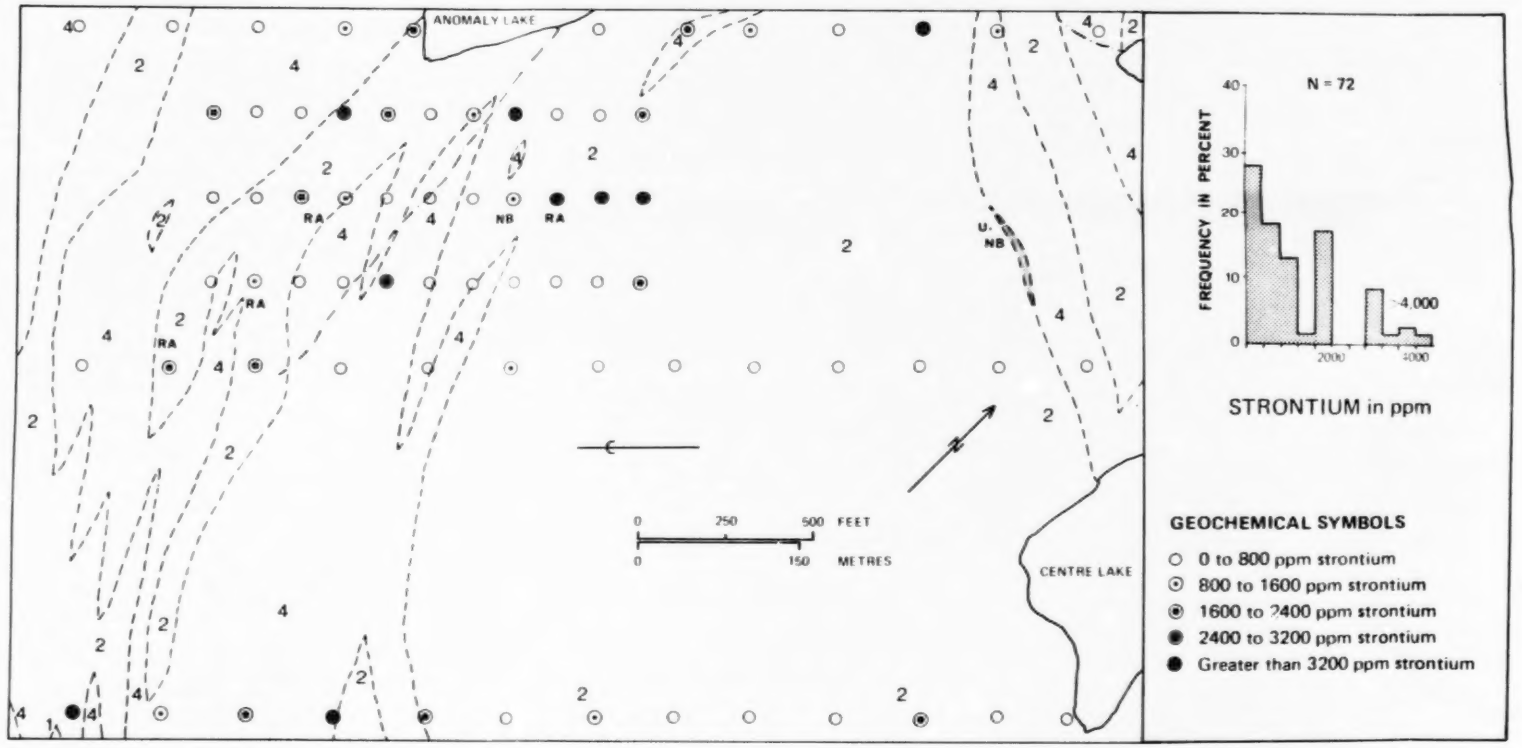
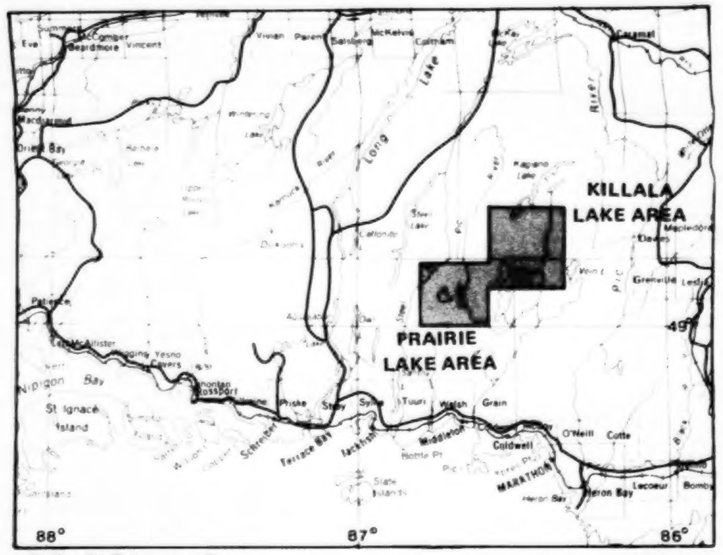
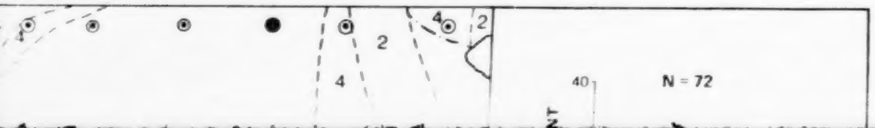


Figure 48 – Geochemical map of strontium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.



LOCATION MAP Scale 1:1 584 000



LEGEND

5	Dike Rocks
4	Carbonatitic Rocks

Figure 46 – Geochemical map of strontium in 'B' horizon soils, Prairie Lake detailed area.

Figure 47 – Geochemical map of strontium in -250 mesh till samples, Prairie Lake detailed area.

Fig

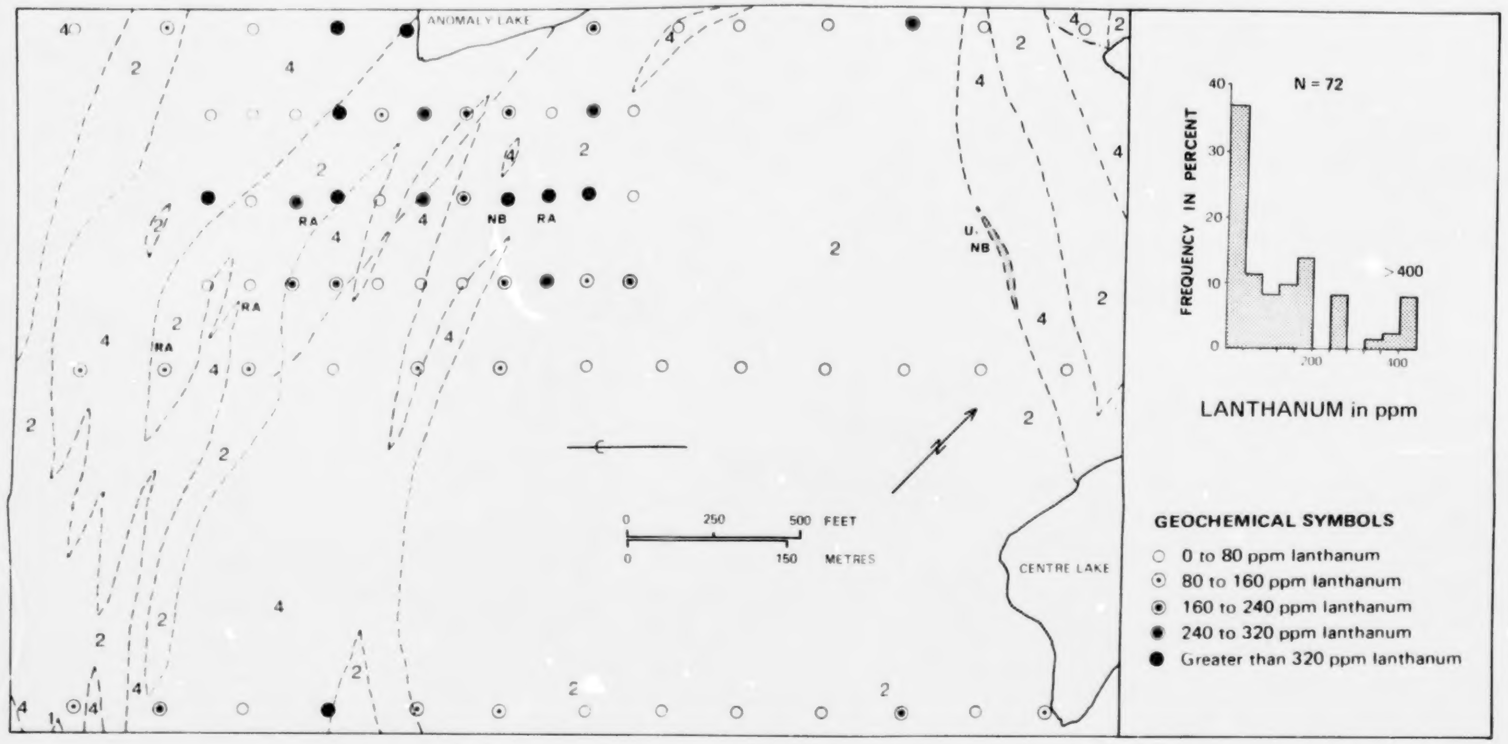


Figure 49 – Geochemical map of lanthanum in 'B' horizon soils, Prairie Lake detailed area.

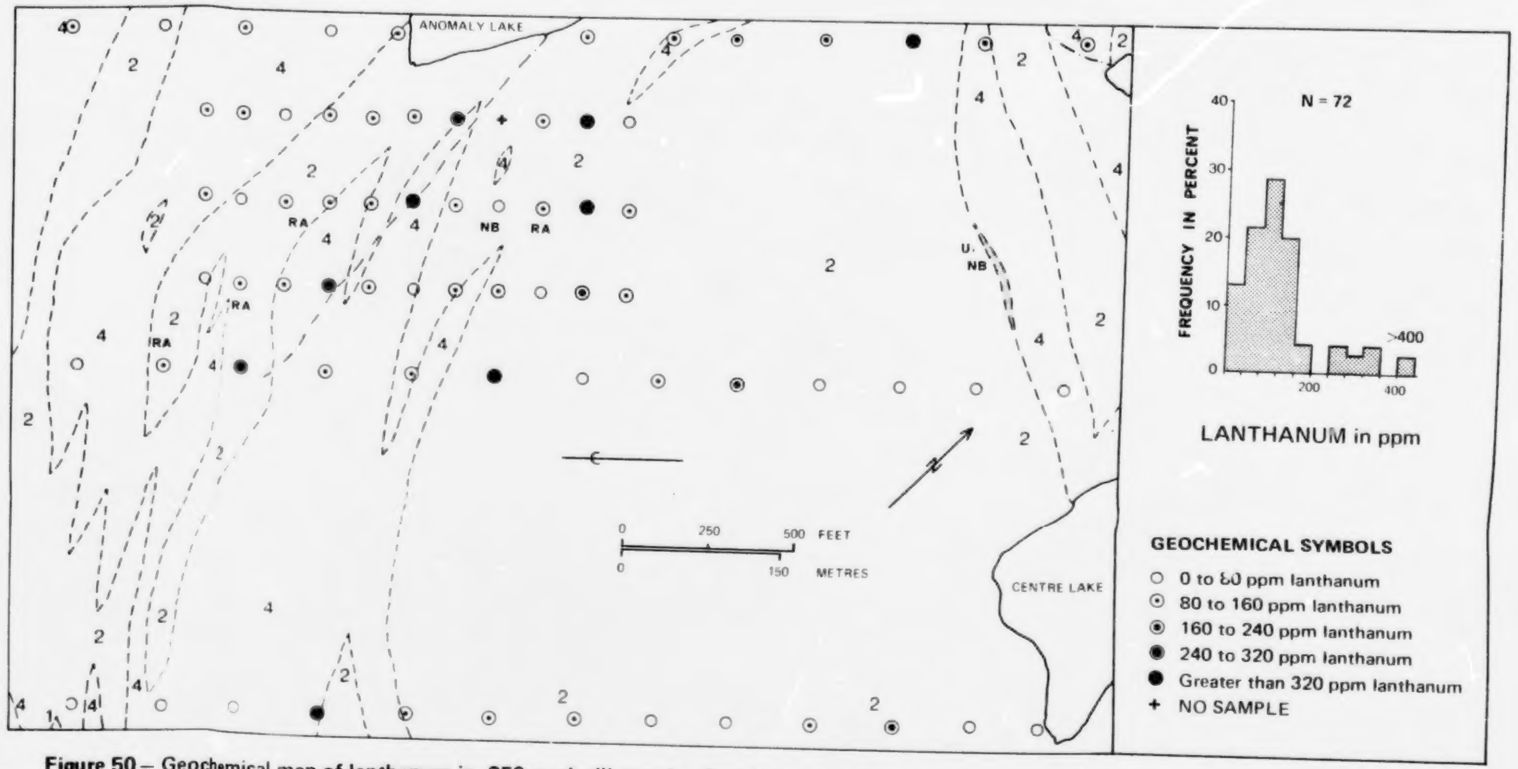
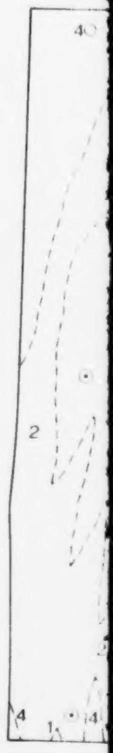


Figure 50 – Geochemical map of lanthanum in -250 mesh till samples, Prairie Lake detailed area.



Figure

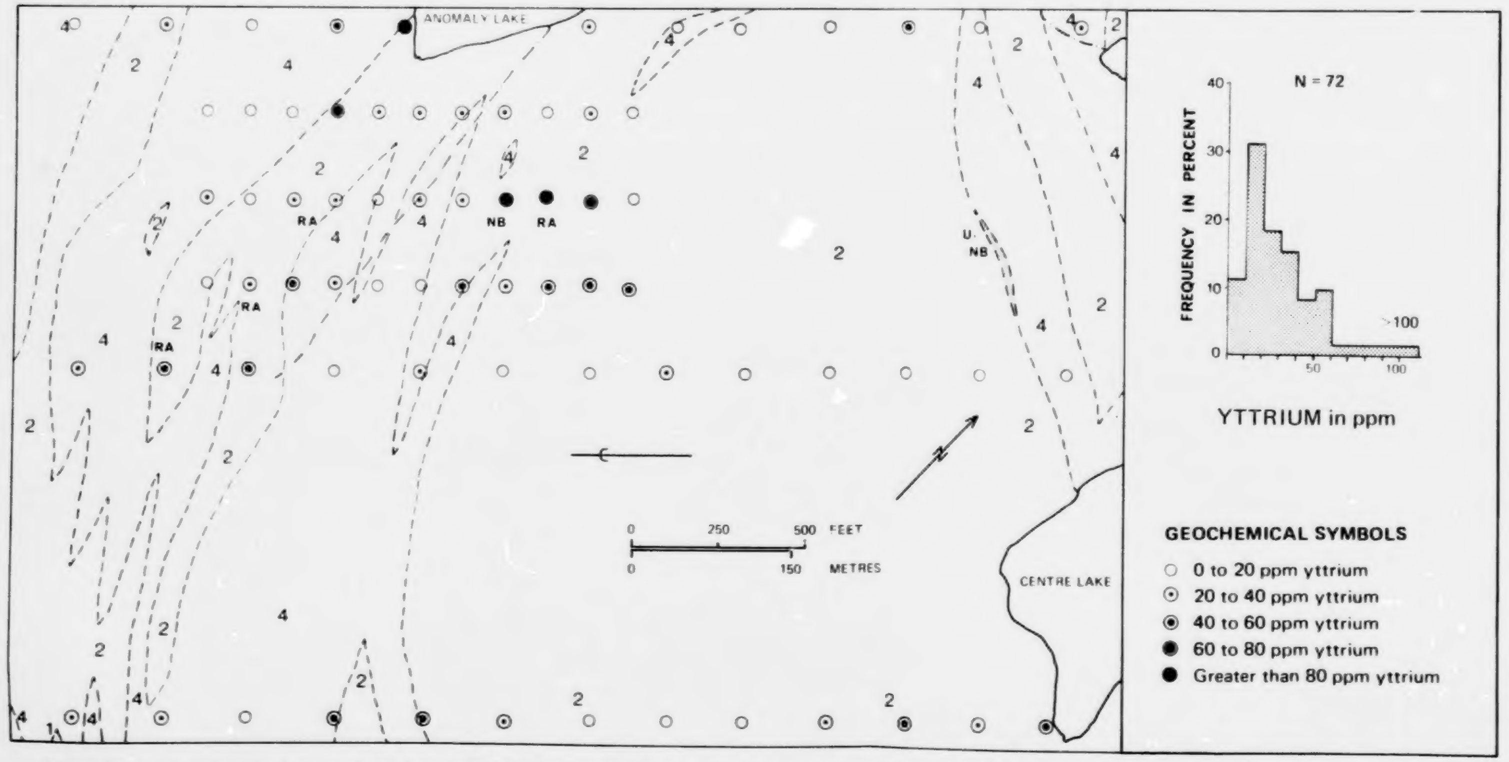


Figure 52 – Geochemical map of yttrium in 'B' horizon soils, Prairie Lake detailed area.

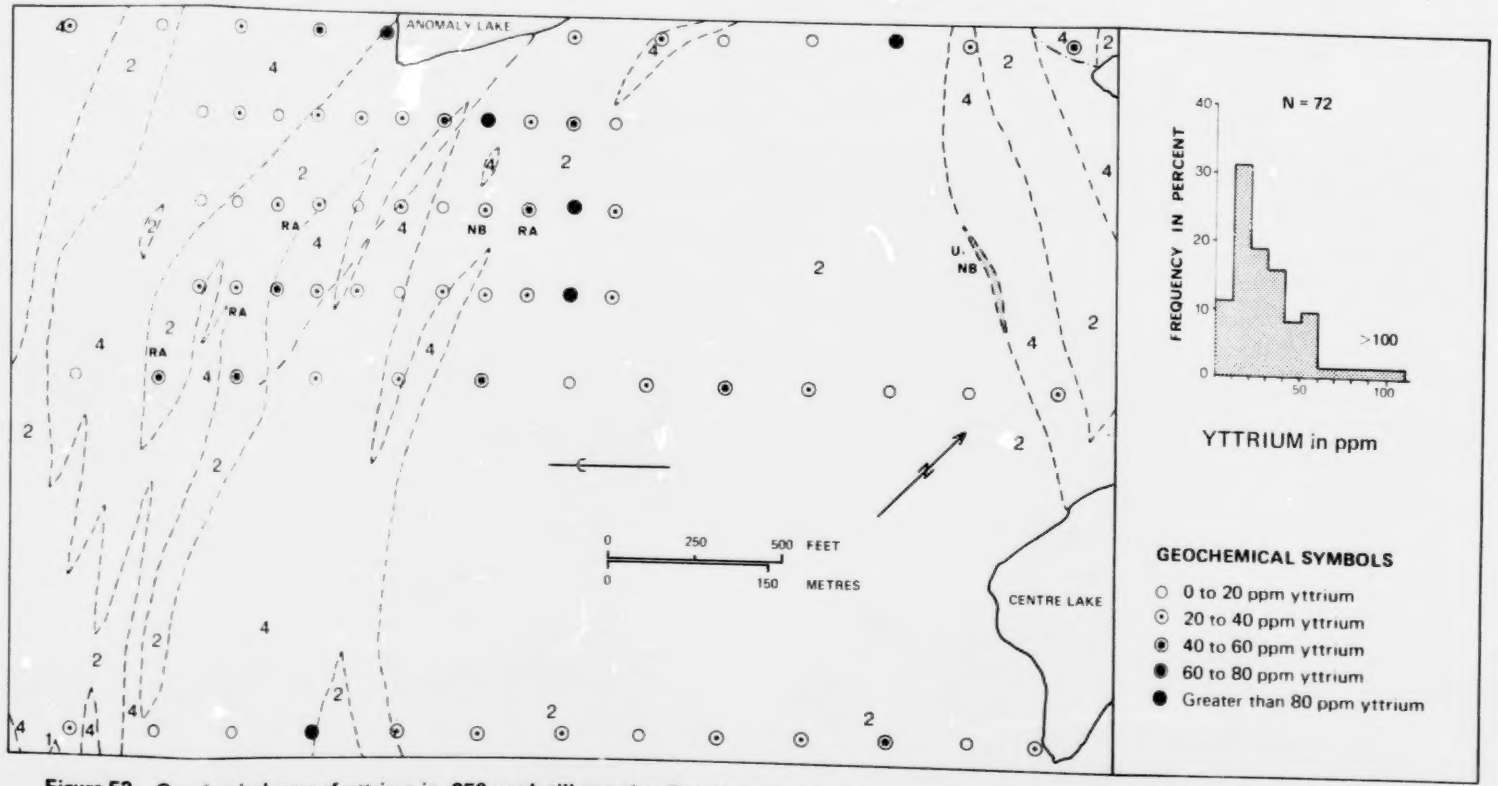
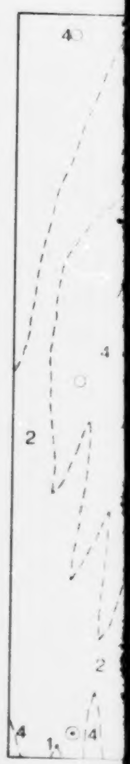
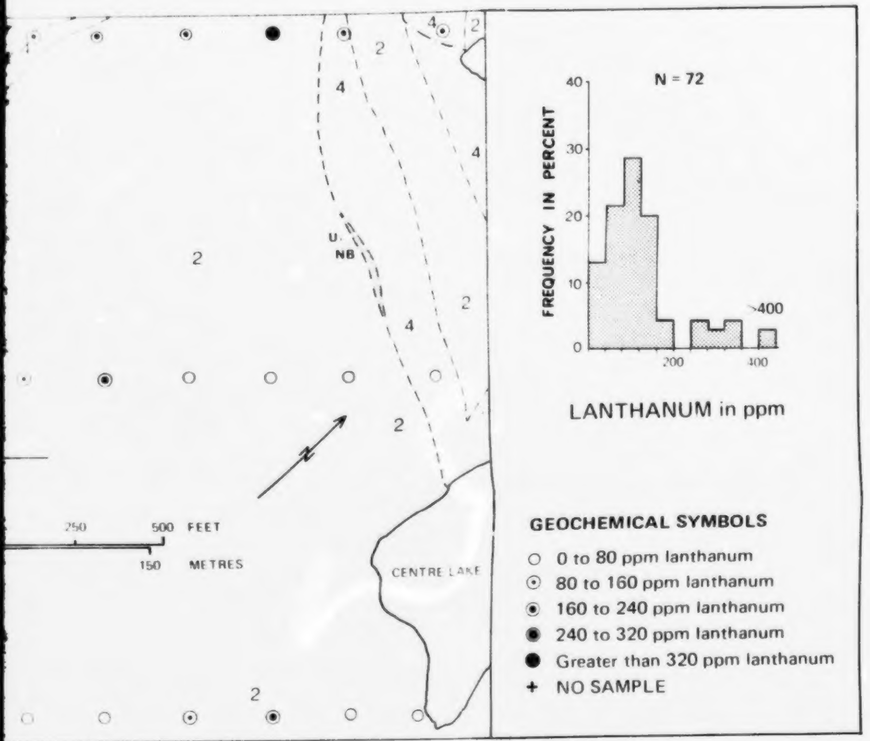


Figure 53 – Geochemical map of yttrium in -250 mesh till samples, Prairie Lake detailed



mples, Prairie Lake detailed area.

Figure 48 – Geochemical map of strontium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.



amples, Prairie Lake detailed area.

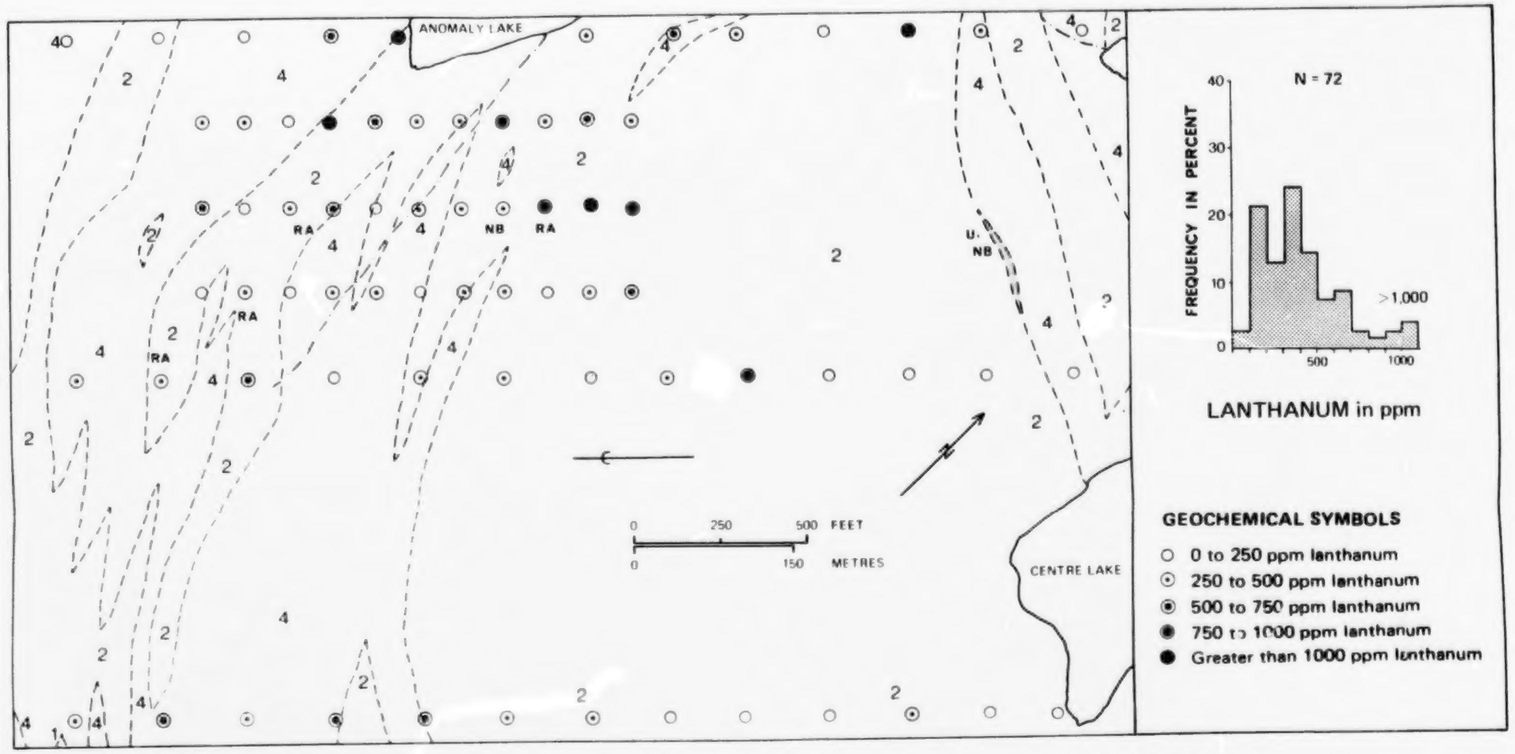
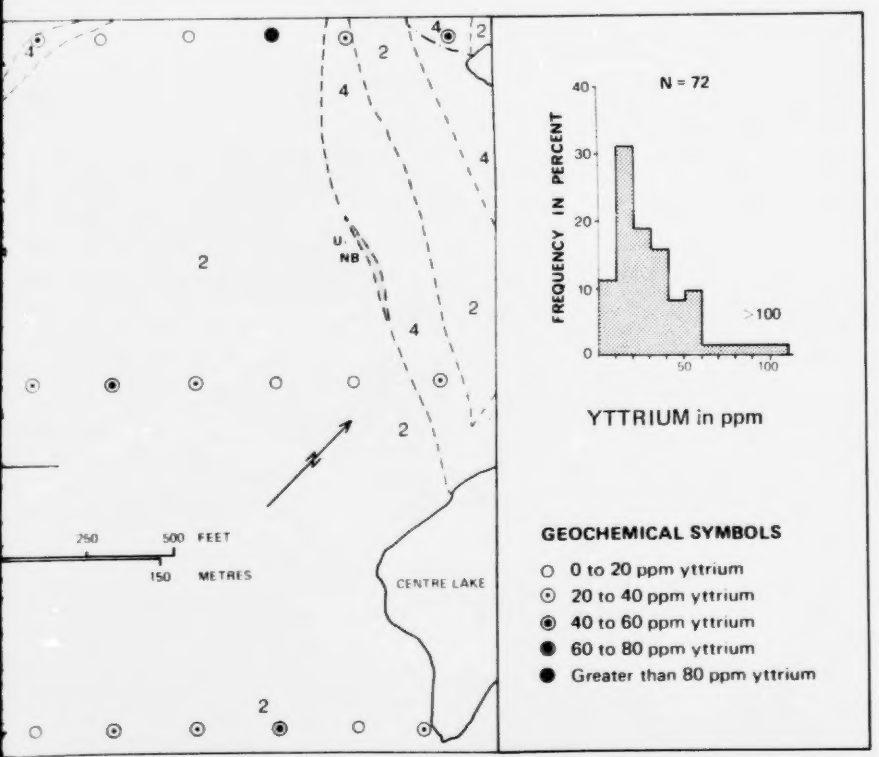


Figure 51 – Geochemical map of lanthanum in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.



mples, Prairie Lake detailed area.

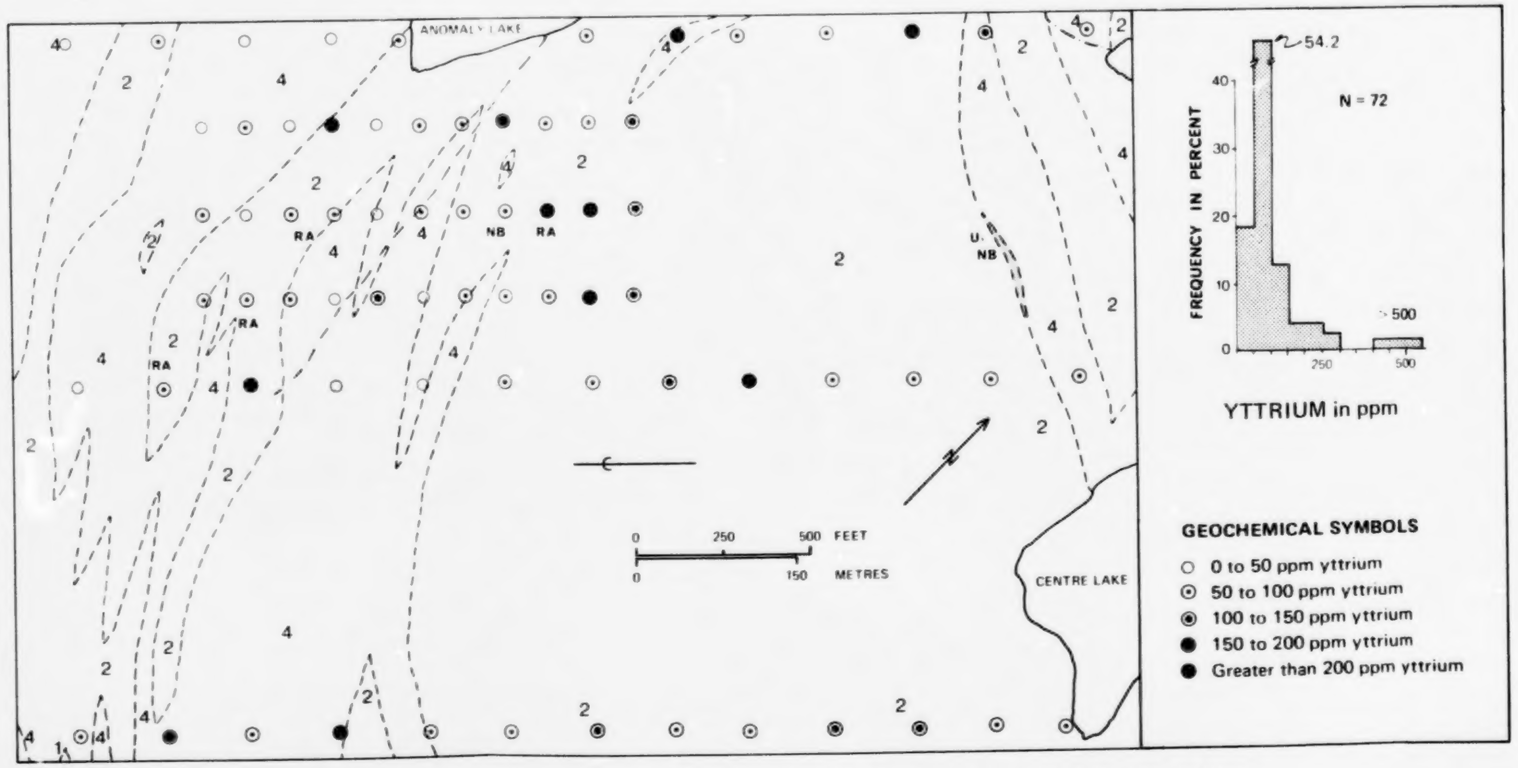


Figure 54 – Geochemical map of yttrium in heavy mineral separates of -60 +250 mesh till samples, Prairie Lake detailed area.

LEGEND

5	Dike Rocks
4	Carbonatitic Rocks
3	Syenitic Rocks
2	Ijolitic Rocks
1	Granitic and Fenitized Rocks
- - -	Geological Contact
— —	Fault, inferred
⟵	Glacial Transport Direction
RA	Radioactivity
U	Uranium Occurrence
Nb	Nobium Occurrence

SOURCES OF INFORMATION

Geochemical field work by L.G. Closs and assistants, 1974.

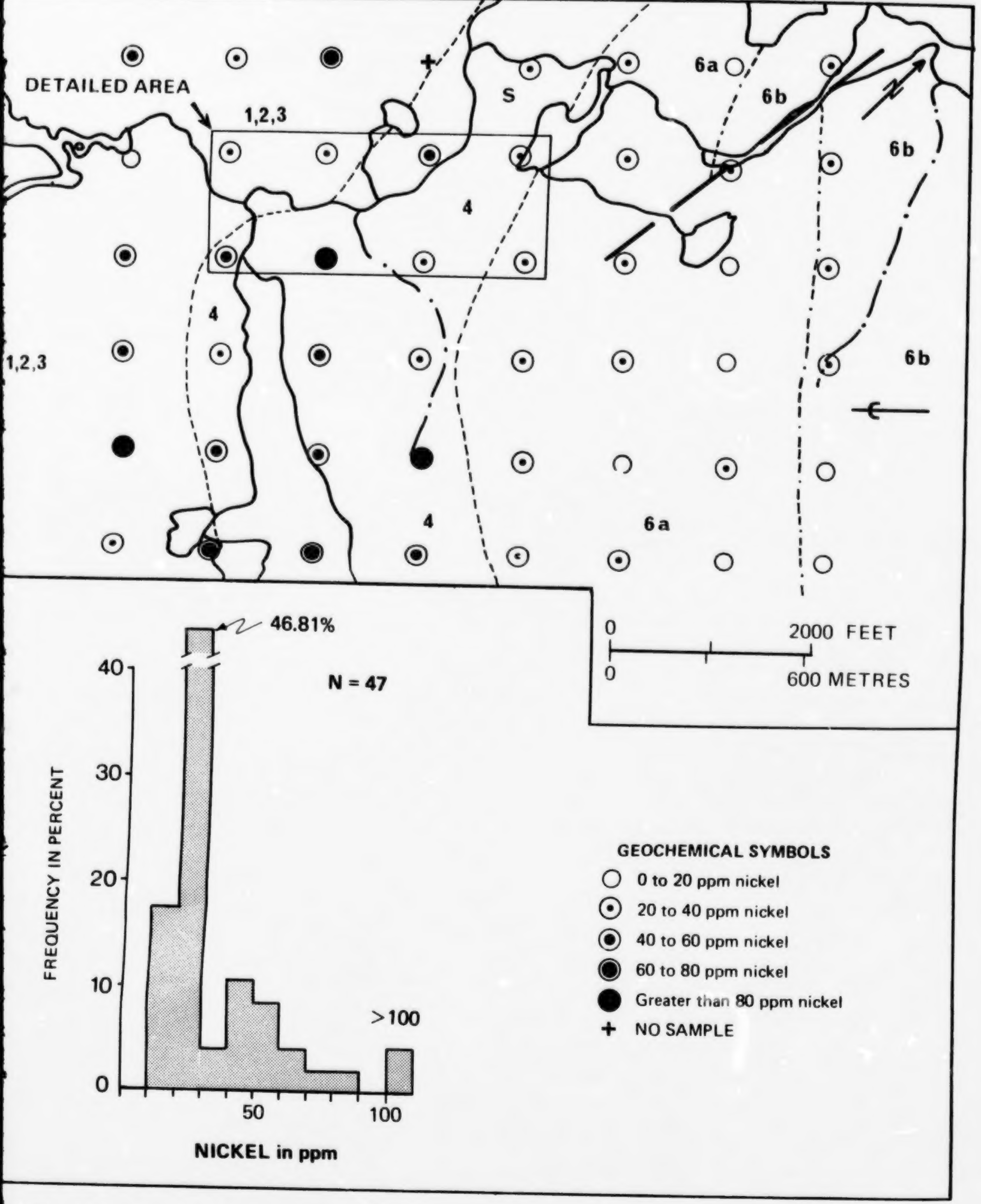
Analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Geology by R.P. Sage, D. Bathe, and assistants, 1975.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Base map derived from unpublished geological map prepared for Newmont Mining Corporation of Canada Limited.

Magnetic declination approximately 3° W, 1980.



ure 63 – Geochemical map of nickel in 'B' horizon soils, Killala Lake area.

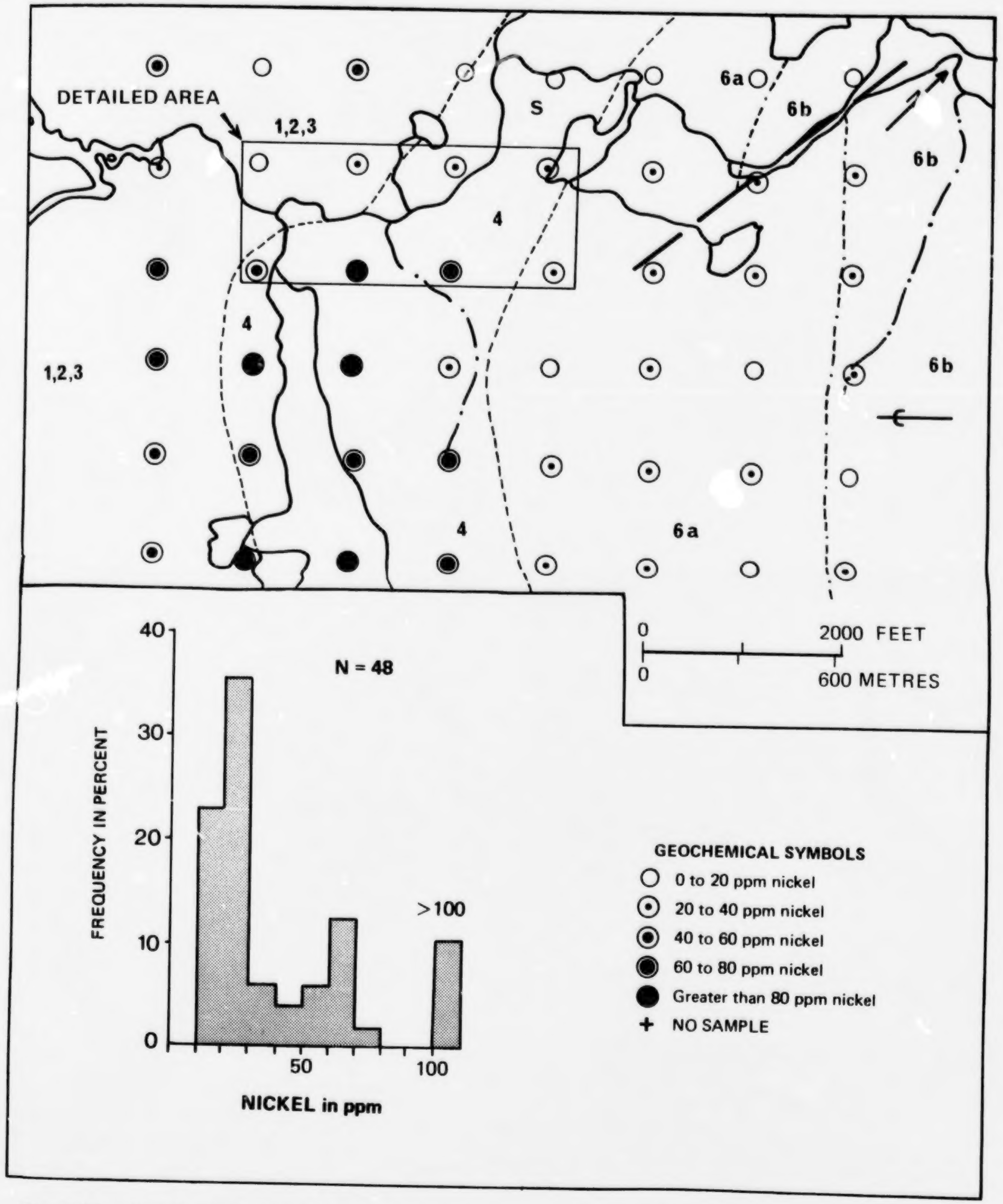


Figure 64 – Geochemical map of nickel in -250 mesh till samples, Killala Lake area.

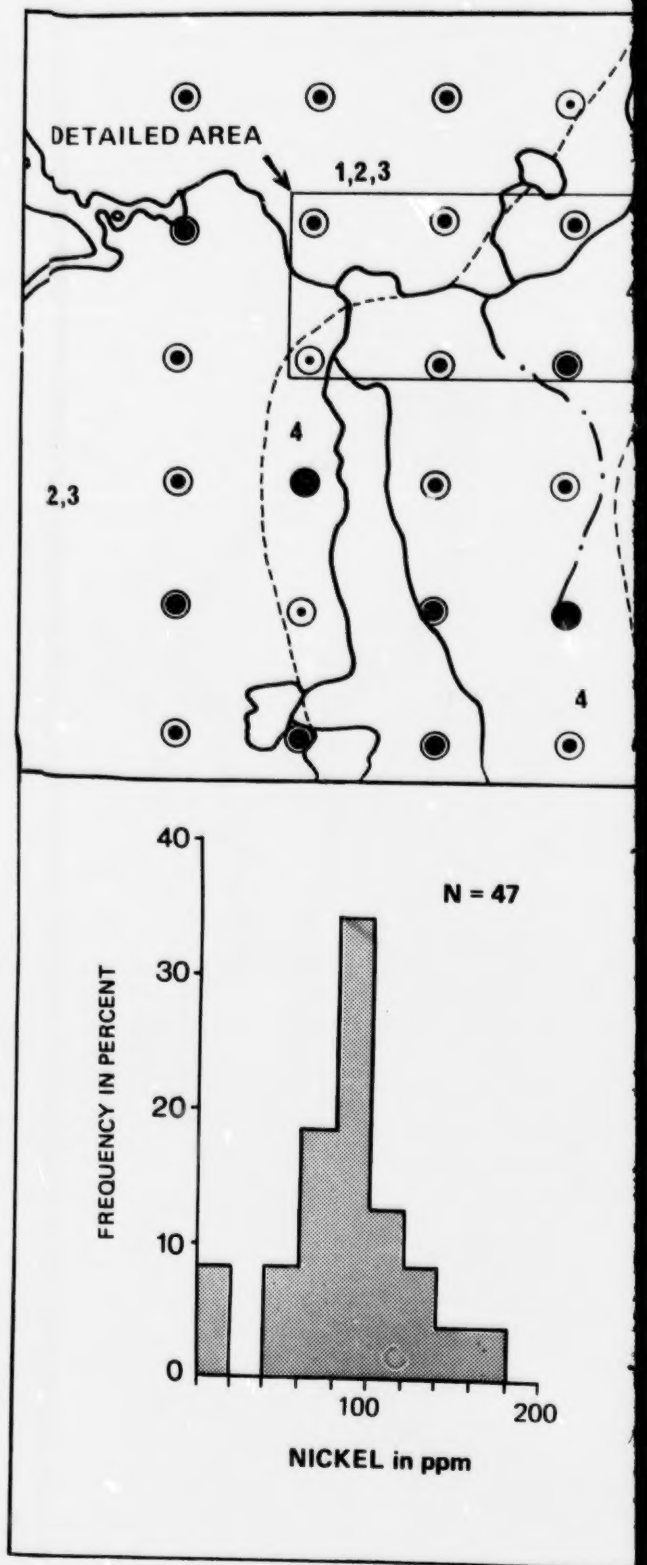
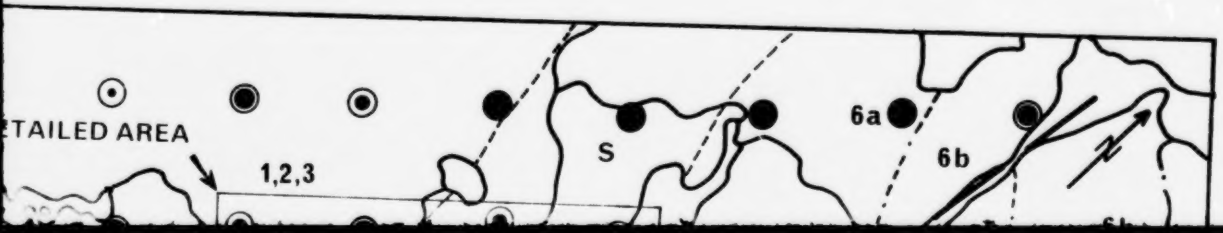


Figure 65 – Geochemical map of nickel in heavy miner

Lake area.



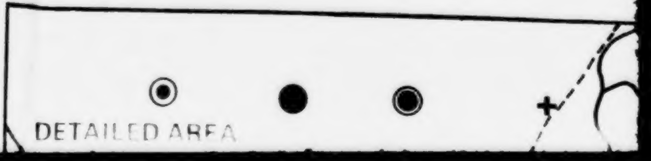
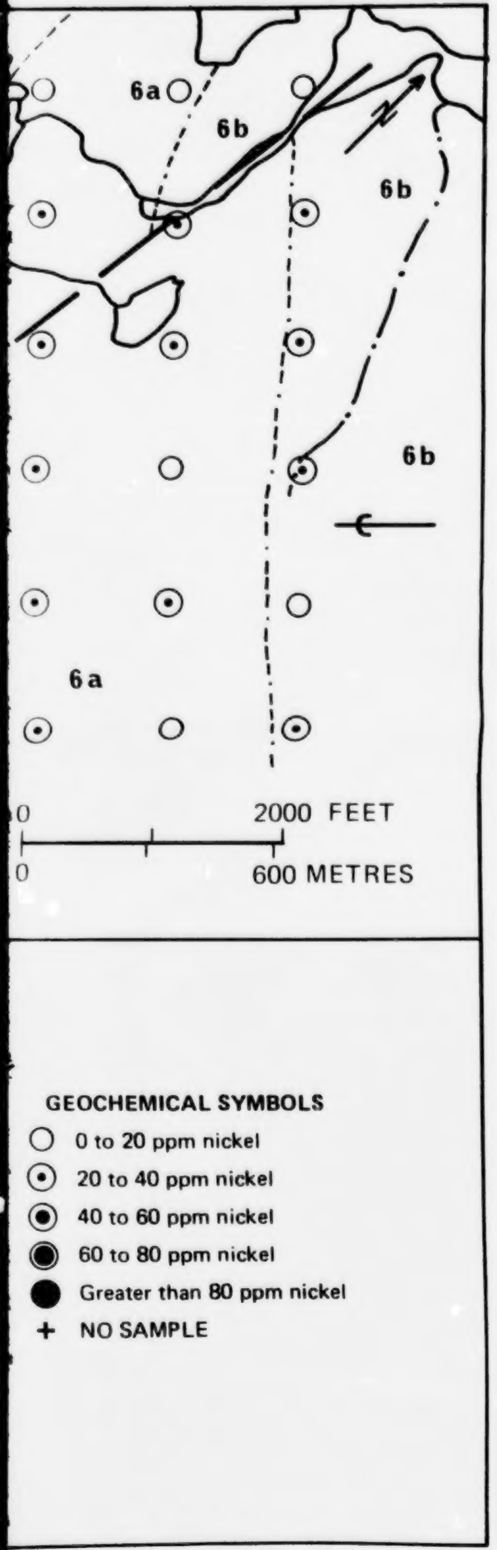


Chart C-2
Figures 62 to 68 (inclusive)



illala Lake area.

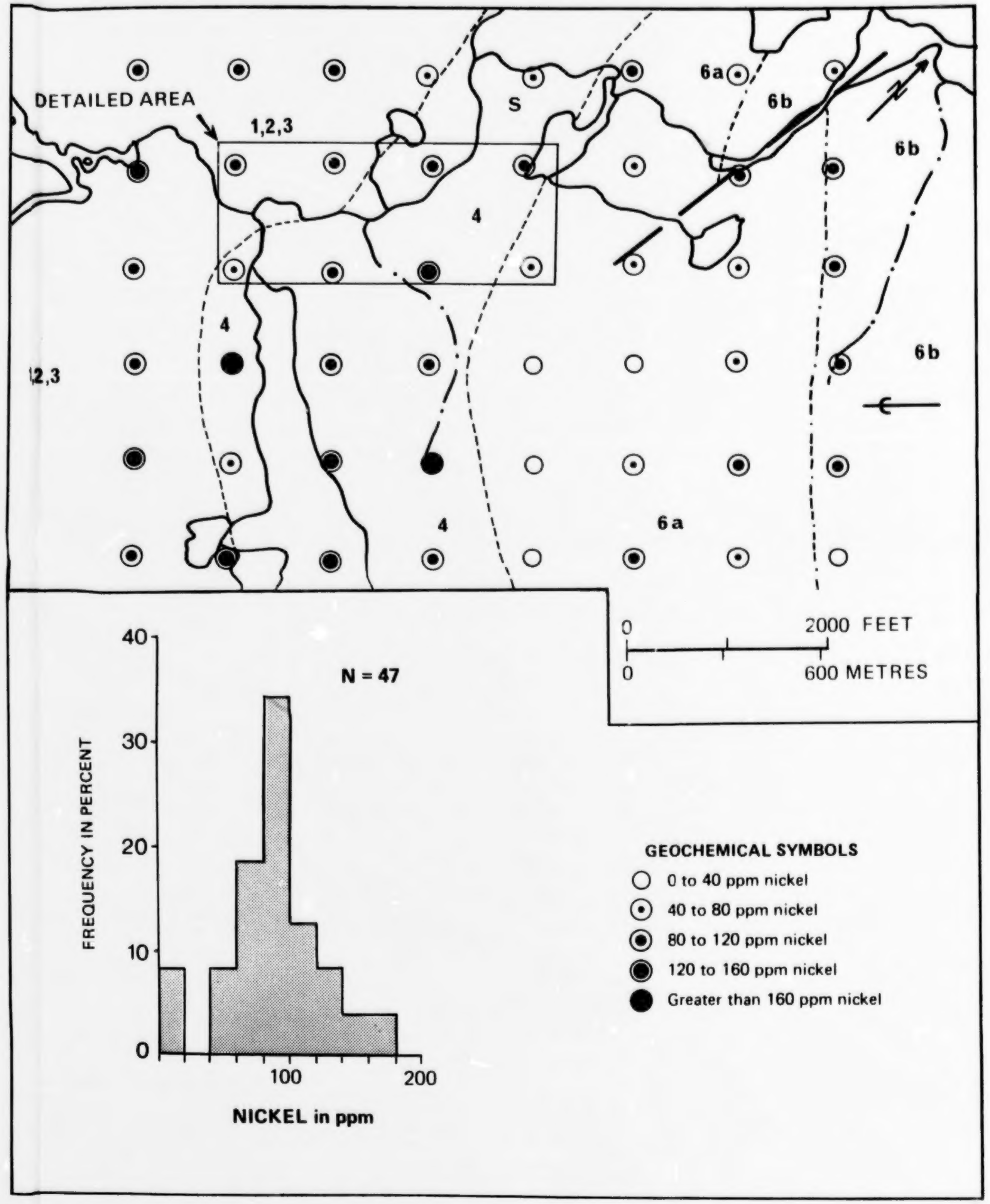


Figure 65 — **Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Killala Lake area.**

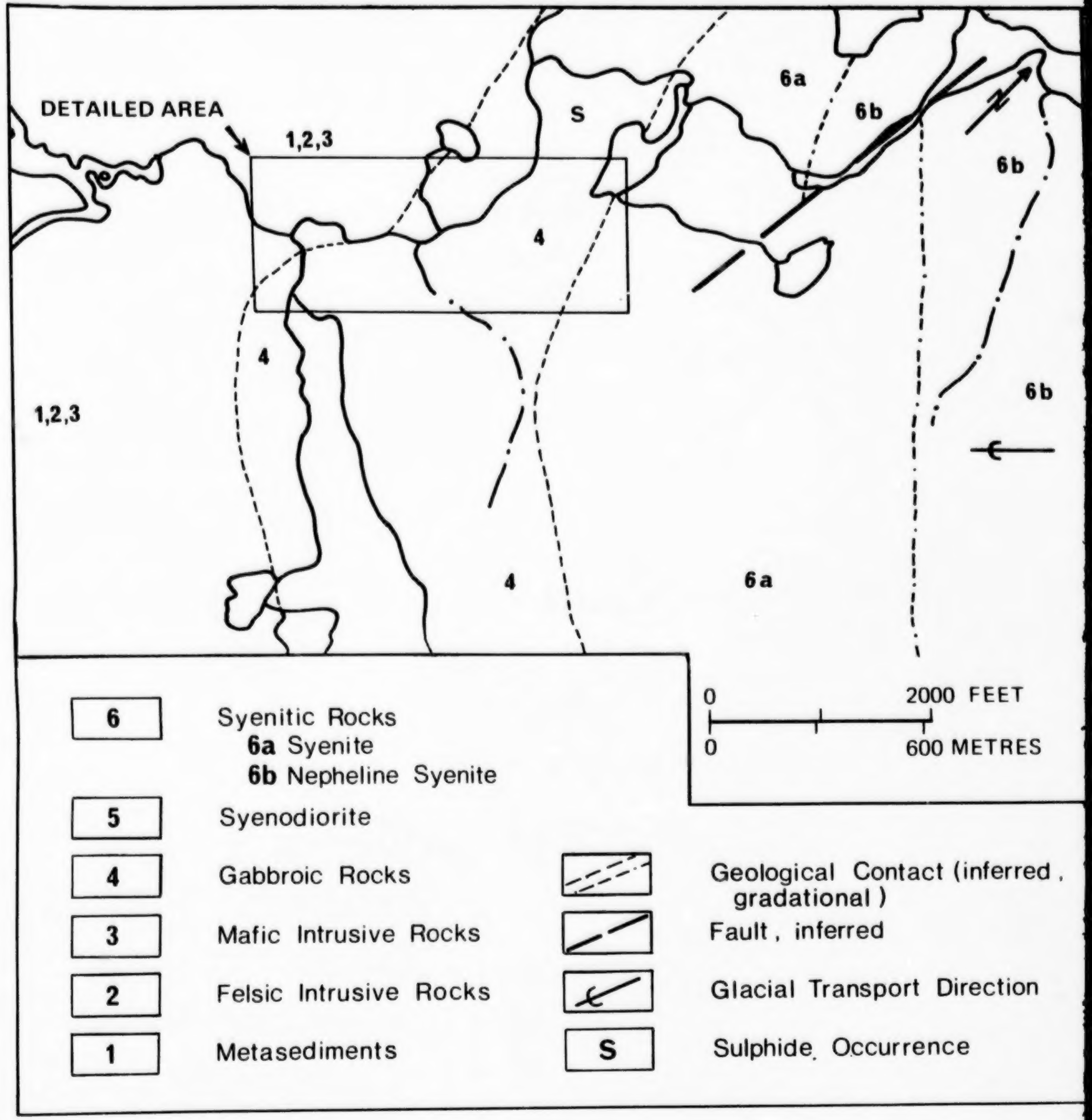


Figure 62 — **Bedrock geology, Killala Lake area.**

CHART C–2

Geochemical Distribution of NICKEL, NIOBIUM, LANTHANUM, AND BARIUM IN OVERBURDEN

gure 63 – Geochemical map of nickel in 'B' horizon soils, Killala Lake area.

Figure 64 – Geochemical map of nickel in -250 mesh till samples, Killala Lake area.

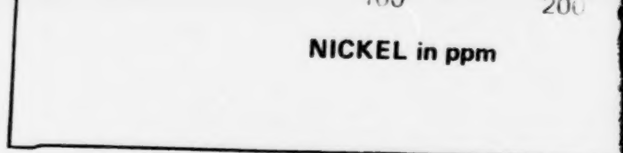
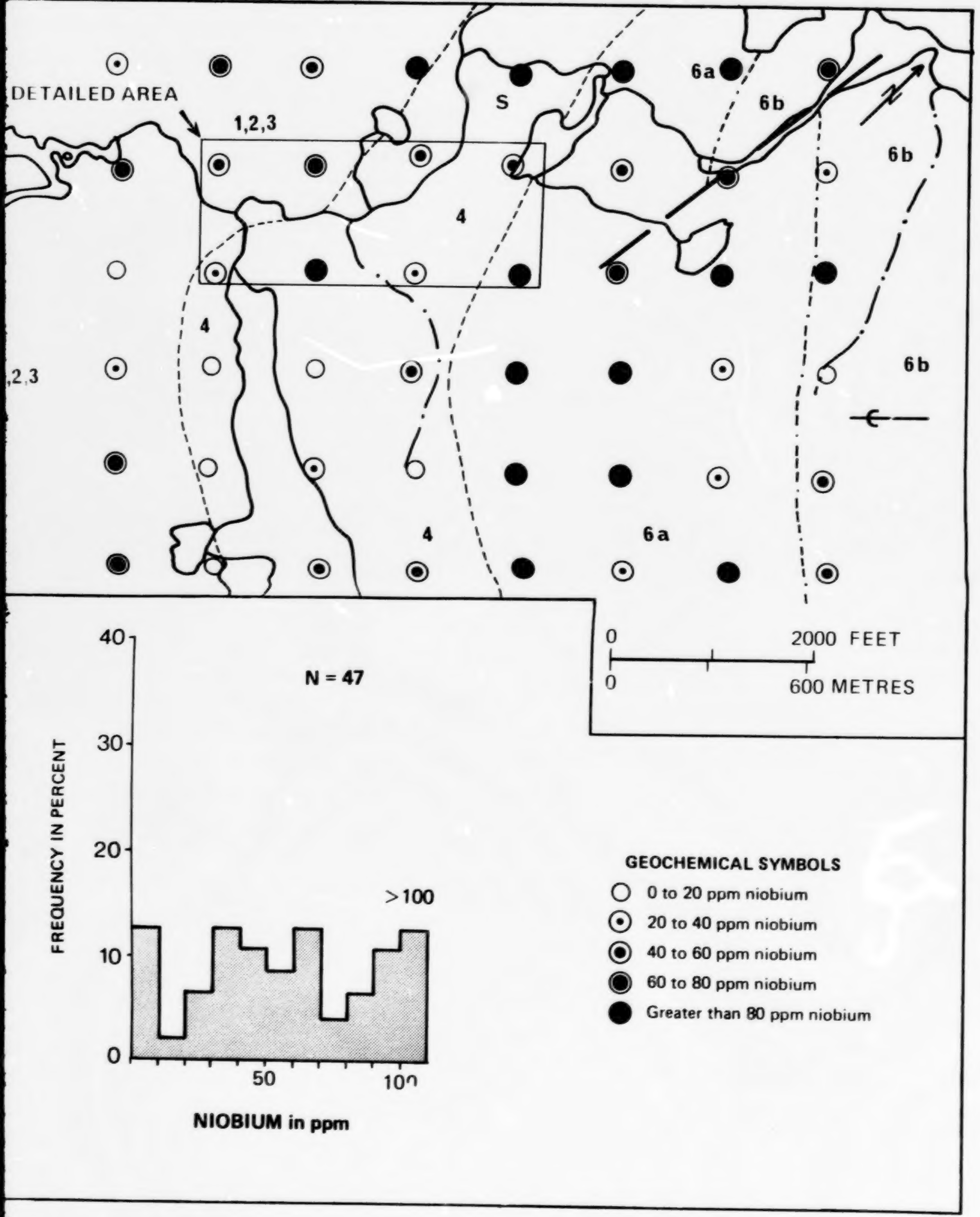


Figure 65 – Geochemical map of nickel in heavy mi
Lake area.



gure 66 – Geochemical map of niobium in heavy mineral separates of -60 +250 mesh till samples, Killala Lake area.

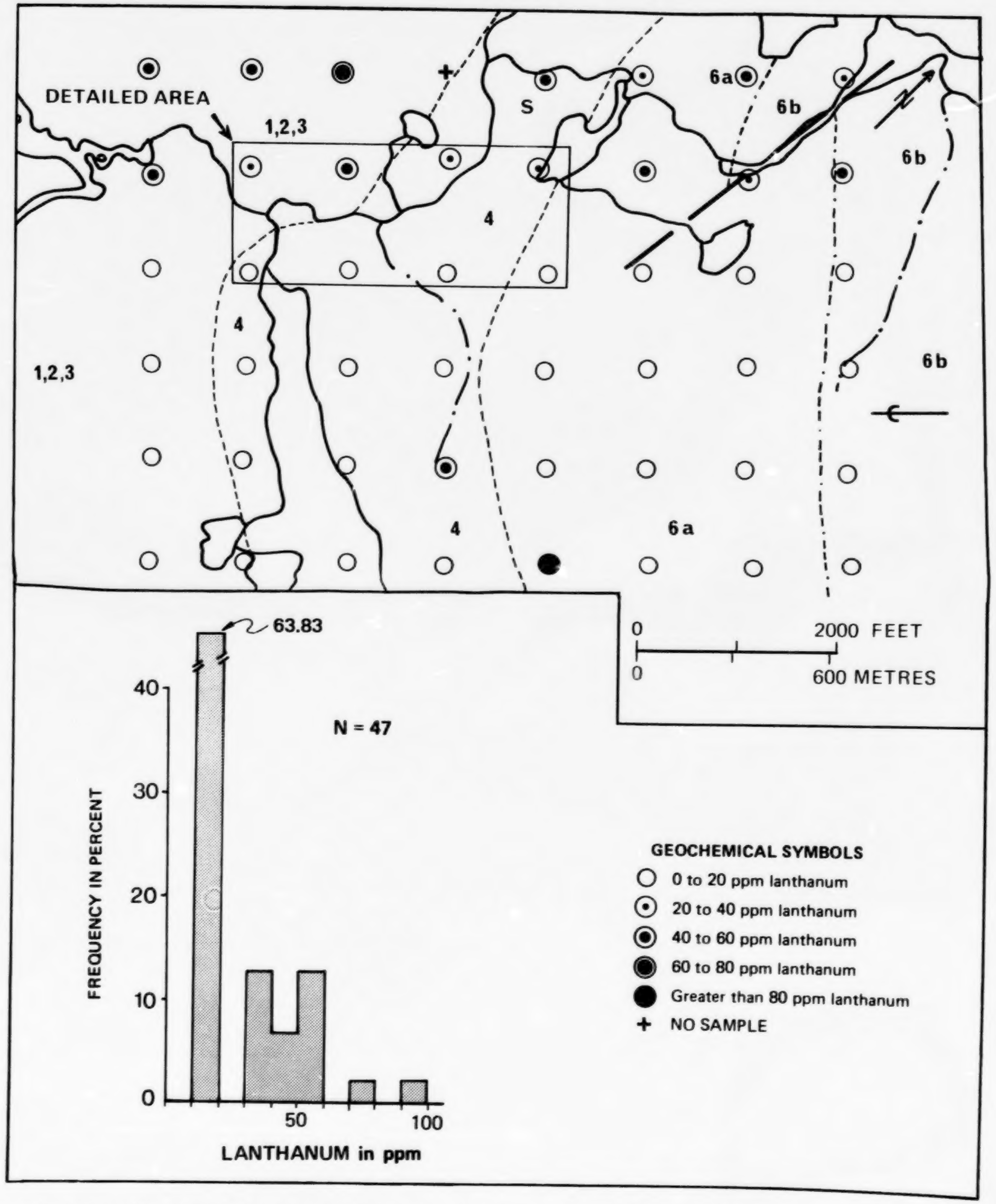


Figure 67 – Geochemical map of lanthanum in 'B' horizon soils, Killala Lake area.

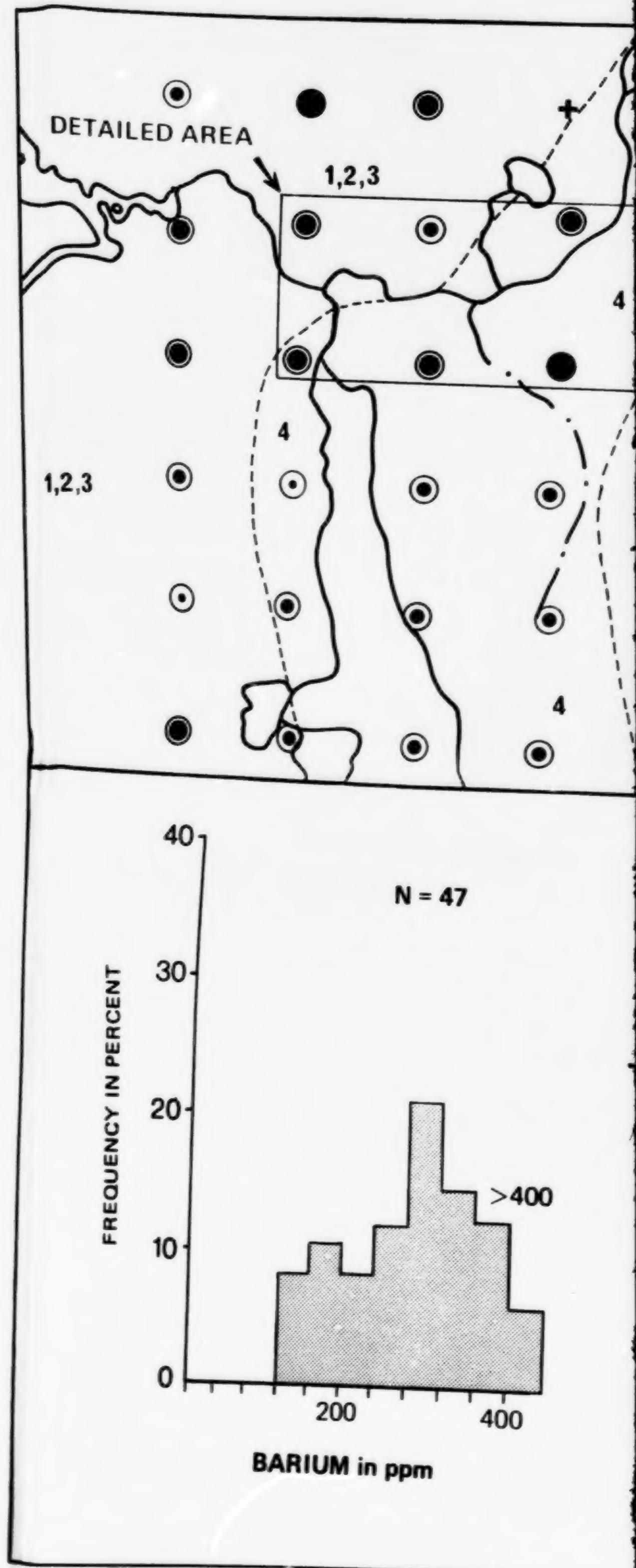
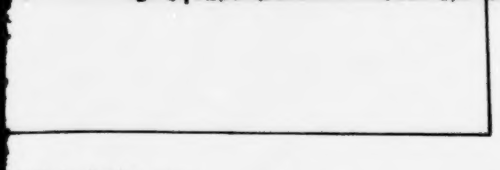
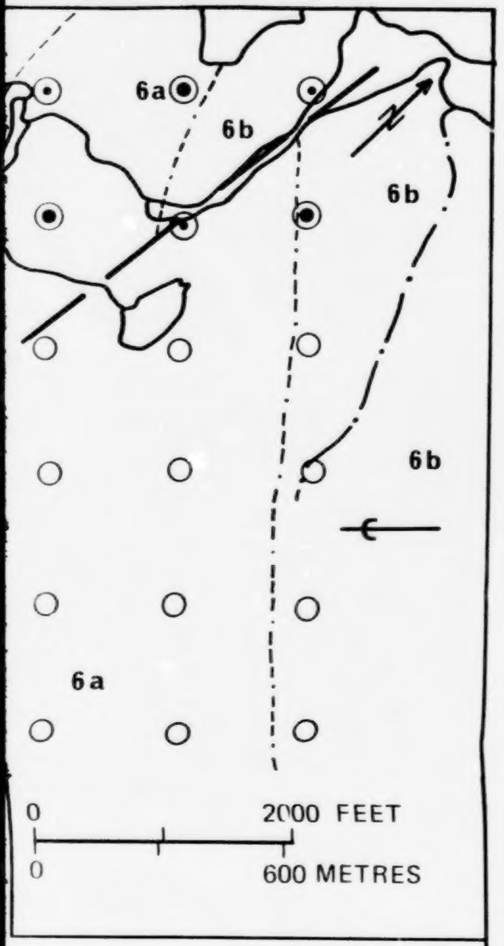


Figure 68 – Geochemical map of barium in 'B' horiz



Killala Lake area.

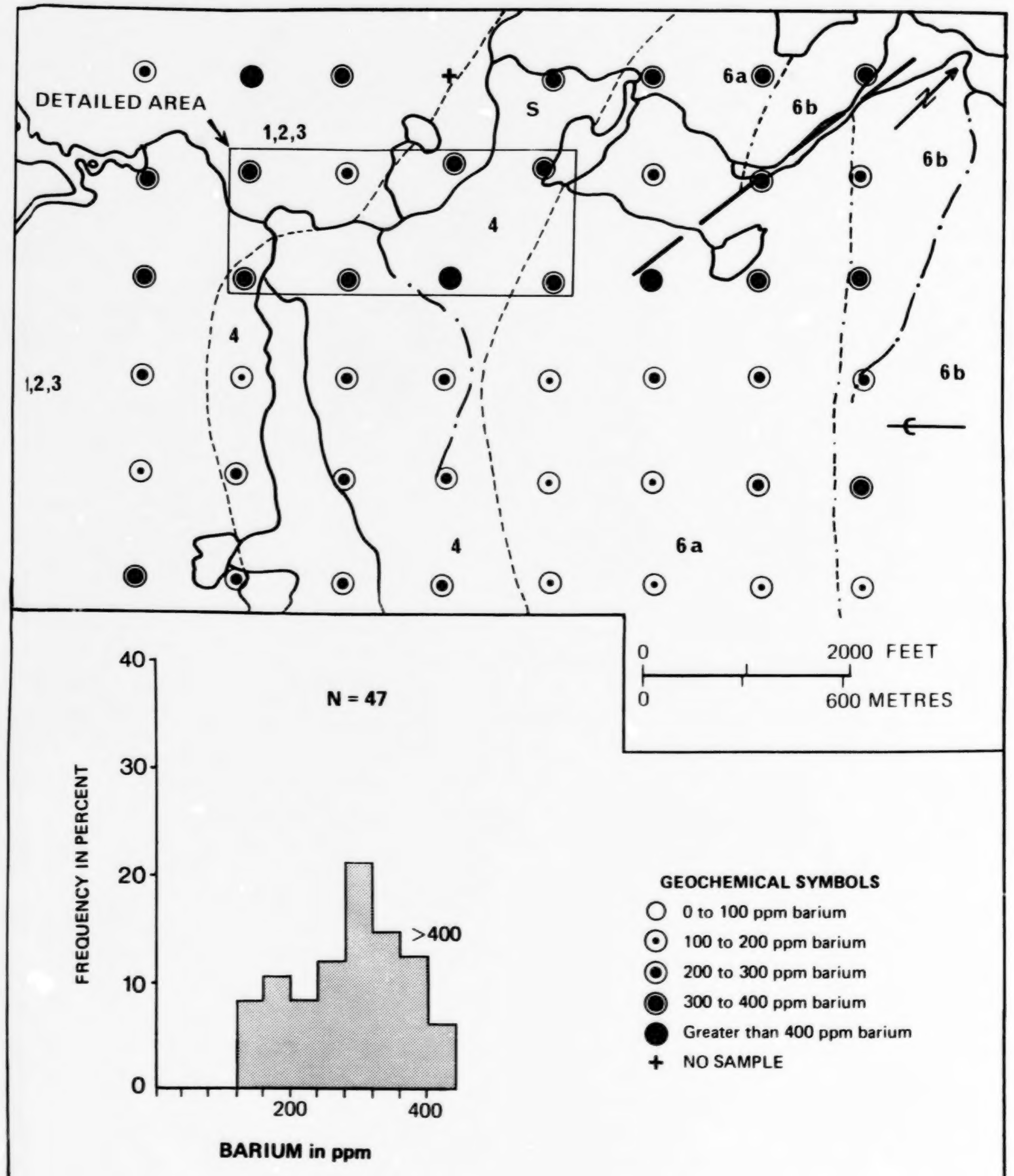
Figure 65 – Geochemical map of nickel in heavy mineral separates of -60 +250 mesh till samples, Killala Lake area.



GEOCHEMICAL SYMBOLS

- ○ 0 to 20 ppm lanthanum
- ⊙ 20 to 40 ppm lanthanum
- ◎ 40 to 60 ppm lanthanum
- ◉ 60 to 80 ppm lanthanum
- ● Greater than 80 ppm lanthanum
- + NO SAMPLE

llala Lake area.



GEOCHEMICAL SYMBOLS

- ○ 0 to 100 ppm barium
- ⊙ 100 to 200 ppm barium
- ◎ 200 to 300 ppm barium
- ◉ 300 to 400 ppm barium
- ● Greater than 400 ppm barium
- + NO SAMPLE

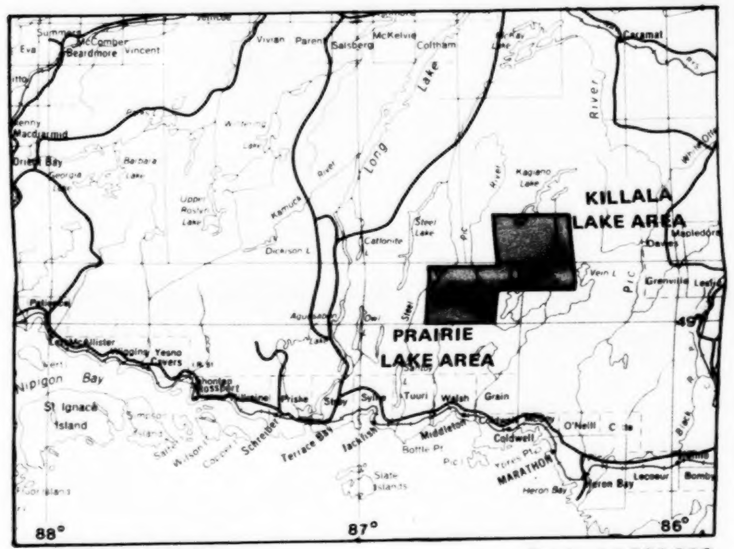
Figure 68 – Geochemical map of barium in 'B' horizon soils, Killala Lake area.

CHART C-2

Geochemical Distribution of NICKEL, NIOBIUM, LANTHANUM, AND BARIUM IN OVERBURDEN

KILLALA LAKE AREA

District of Thunder Bay



LOCATION MAP Scale 1:1 584 000

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Base map derived from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

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